

SECTION 5 SCIENTIFIC COMMITTEE

REPORT OF THE 22nd SCIENTIFIC COMMITTEE MEETING

EXECUTIVE SUMMARY

The 22nd meeting of the Scientific Committee was held in Tórshavn, Faroe Islands from 9-12 November, 2015. The SC remembered Dorete Bloch from the Faroe Islands, an SC member from 1992-2009, who passed away this year—she will be missed by all.

Reports from 3 working groups (WGs) were presented: Large Whale Assessment WG (ANNEX 1), NAMMCO-JCNB Joint WG (ANNEX 2), and the Survey Planning WG (ANNEX 3). The SC also discussed the NASS Steering Committee's post-survey report to the FAC (ANNEX 4). National Progress Reports were received by member countries and observers. The SC also heard special presentations on whale research projects in Japan.

Cooperation with other organisations

In the IWC SC in recent years, there has been movement for more funding to be allocated to conservation issues rather than management related issues, which has gained some support in the Commission. This could create further delays completing work relevant to NAMMCO such as assessment of whale stocks. However, this may also allow more flexibility to survey on 10 year cycles rather than 6 years, which is not of concern from a conservation perspective and would allow funding to be used for surveys of other species.

In ASCOBANS, one area of potential cooperation is on the assessment of harbour porpoises since it is a shared stock. Several ASCOBANS participants expressed interest in working with NAMMCO on exploring the idea of convening a joint meeting reviewing the status of harbour porpoises.

Several ICES WGs have work of relevance to NAMMCO: Working Group on Marine Mammal Ecology (WGMME), the Working Group on By-catch of Protected Species (WGBYC), and the Joint ICES/NAFO/NAMMCO Working Group on Harp and Hooded Seals (WGHARP). NAMMCO's request to join the WGHARP was accepted by ICES and NAFO this year, which will hopefully help facilitate requests being submitted to the WG.

The NAMMCO-JCNB Joint Working Group agreed on Rules of Procedure, which were also accepted by the NAMMCO SC.

Several Arctic Council WGs have work of relevance to NAMMCO, including the CAFF and PAME.

Environmental/Ecosystem Issues

In the Barents and Norwegian Seas, cod abundance has increased, and its range has extended northwards in recent years. One implication of this is a new overlap of feeding grounds with harp seals and minke whales, two other important top predators in the area. Both these mammal species have exhibited declines in body condition in recent years, and competition for food with the increasing cod stock is suggested as a possible explanation.

In Iceland during the last two decades, substantial increases in sea temperature and salinity have been reported in Icelandic waters. Concurrently, pronounced changes have occurred in the distribution and abundance of several cetacean species and their prey since regular monitoring began in 1987. A northward shift in summer distribution of capelin and a crash in the abundance of sand eel are suspected to be the primary cause of the recent shift in distribution of common minke whales away from Icelandic coastal waters. Continued monitoring of the distribution and abundance of cetaceans is essential for conservation and management of the cetacean populations and as a part of wider studies of ongoing changes in the ecosystem.

By-catch

By-catch remains an issue of importance, not only in NAMMCO countries, but in many other areas. The SC recommended holding a By-catch WG (BYCWG) that includes participants from outside the marine mammals sphere and the SC (e.g. fishery experts) and outside NAMMCO.

Impacts of Human Disturbance in the Arctic

The Symposium organised by NAMMCO “Impacts of Human Disturbance on Arctic Marine Mammals” was held 13-15 October 2015. Concerns were raised at both the Symposium and the SC meeting about a Canadian mining project currently under development in the Canadian Arctic, the *Mary River Project* operated by *Baffinland Iron Mines Corp*, a project that continues expanding, currently with the prospect of year-round shipping through the heavy pack ice in Baffin Bay. It will have severe consequences for the large numbers of marine mammals using the area in summer and winter, not only narwhals but also belugas, bowheads, ringed seals and walruses, with unpredictable consequences for the populations themselves but also for the accessibility to hunting and/or its sustainability.

Other industrial activities that were addressed at the symposium as being particularly important as disturbance factors for marine mammals were seismic exploration in Canada, and West and East Greenland. The SC **draws the attention** of the NAMMCO Council to the potentially severe consequences of these projects. The SC noted that these industrial activities will also likely have impacts on the hunting of these species, and could affect the advice that is given by this SC.

SEALS AND WALRUS

Harp seals

Russia (PINRO) have been conducting surveys in the White Sea for pup production since 1998. Surveys since 2004 have indicated a significant reduction in pup production. The reasons for the decline are not known, although one hypothesis is that there was a decline in reproduction in adult females, and an increase in the age of maturity. Results from an aerial survey flown in 2013 gave an estimated pup production of 128,786 (95% CI 98,188 to 159,364).

Although the population assessment model used for the White Sea/Barents Sea harp seal population provided a poor fit to the pup production survey data, ICES has decided to continue to use the model which estimated a total 2015 abundance of 1,368,200 (95% C.I. 1,266,300 – 1,509,378). Despite the fact that this population is now classified as data poor, ICES expressed concerns over the high removals and declining population resulting from the PBR estimations, and concluded that the estimated equilibrium catches were the most preferred option. The equilibrium catch level is 19 200 1+ animals, or an equivalent number of pups (where one 1+ seal is balanced by 2 pups), in 2015 and subsequent years.

The use of traditional photo aircrafts to assess seal populations in remote areas, such as the West Ice, is expensive and becoming more difficult to operate. IMR (Norway), with funding from the Norwegian Research Council (NRC), has now started experiments with alternative (and cheaper) methods to perform photo-based aerial surveys of seals in the West Ice. Two research surveys have been carried out to the West Ice with the aim to test the usefulness of UAVs (Unmanned Aerial Vehicles), operated by the Northern Research Institute (Norut), to perform aerial photographic surveys of harp and hooded seal whelping patches on the drift ice. Experience obtained from using the UAVs, and the quality of the images taken, were promising. Both harp and hooded seals, including pups, were easily identified on the images taken at an altitude of 300 m (the usual altitude for photographing during traditional surveys).

A new population model is being developed for harp seals in the Barents and White Seas that is more flexible in capturing the dynamics of the observed pup production data. The current management model predicted that the pup abundance will have a slight increase over the next 15 years, whereas the new (state-space) model predicted that the pup abundance will increase substantially. The state-space model show some promising results and might be a step forward towards more realistic modelling of the population dynamics of the Barents Sea/White Sea harp seal population.

A recent paper using a new genetic analysis supports the hypothesis that harp seals comprise three genetically distinguishable breeding populations, in the White Sea, Greenland Sea, and Northwest Atlantic.

An analysis of the effects of potential increases in Canadian catches on Greenlandic catches indicates that if catches of young of the year in Canada increase (e.g. if sealskin prices increase), this will significantly reduce the availability of young harp seals for Greenland hunters. Although it is unlikely that Canadian catches will increase in the near future, the situation should be monitored.

The Joint ICES/NAFO/NAMMCO Working Group on Harp and Hooded Seals will meet again in August 2016 at the ICES HQ in Copenhagen, Denmark, to review the status and assess the catch potential of harp and hooded seals in the North Atlantic.

Ringed seals

Ringed seals from the Ilulissat Icefjord (Kangia) in Greenland show differences in size, pelage pattern, and behaviour (e.g., movements and diving patterns) than other ringed seals. The SC **recommended** that a separate management plan be developed for the ringed seal in the Ilulissat Icefjord, to protect this potential separate population from overharvest. The SC also **recommended** genetic sampling work and a new survey for abundance estimate be conducted.

Research in Svalbard has shown dramatic shifts in movement patterns and foraging behaviour of ringed seals before and after a major collapse in sea-ice in Svalbard. These behavioural changes suggest increased foraging effort and thus likely increases in the energetic costs of finding food. Continued declines in sea-ice are likely to result in distributional changes, range reductions and population declines in this keystone arctic species.

The SC noted that there is still not enough information to warrant convening a NAMMCO Ringed Seal WG and recommends that this should occur after new surveys and genetics studies are completed.

Grey Seals

Boat-based visual surveys aimed obtaining a new abundance estimate in Norway were conducted from 2013–2015. Some of the new estimates obtained in mid Norway were much lower than in the previous survey, and quotas were immediately reduced in these areas as a result.

A reporting system has been implemented in the Faroes to obtain estimates of removals at salmon farms, and reports indicate that the removals about 100+ seals per year. The SC is pleased that the Faroes have developed and implemented this system of reporting but noted that removal numbers are high, which is concerning, especially because the population size is unknown. The SC **recommended** that all of the available grey seal data from the Faroes is presented to the Coastal Seals Working Group for review. The SC **recommends** that the CSWG develops specific plans for monitoring grey seals in the Faroes, e.g., obtaining a relative series of abundance (if a full abundance estimate is not possible at this time).

Harbour Seals

Surveys aimed to obtain a new abundance estimate in Norway were conducted from 2011–2015. This has yielded a new point estimate of 7,594 for the species for the entire Norwegian coast. This new estimate is implemented in current management of the species – this management now follows the management plan reviewed by NAMMCO SC in 2011.

In Iceland, results from the partial survey of harbour seals in 2014 shows an appreciable decrease in abundance in the most important haul-out areas. Aerial surveys of harbour seals are planned for 2016, if funds are available. Large uncertainties in abundance and catch statistics, both direct catches and by-catches, make assessments of the present status and sustainability of removals problematic. MRI's 2015 advice to the government declared that in the absence of new abundance estimates, it was unable to evaluate whether the existing management objectives of grey seals and harbour seals are being met.

Coastal Seals Working Group

The SC recommended continuing with the plan for the CSWG to be held in February 2016, where they will assess the status of all populations, address by-catch issues, and review the Norwegian management plans.

Walrus

The assessment and quota advice was updated for the Baffin Bay population. The SC **recommended** that no more than 85 walrus are landed annually in Qaanaaq from 2016 to 2020.

Report of the Scientific Committee

Due to inconsistencies between the two reporting schemes (*Piniarneq* and *Særmeldingsskema*) in Greenland, the SC **recommended** that Greenland should streamline their reporting system, and also conduct a study to investigate why the numbers are different between the reporting schemes.

The SC noted that although this is a shared stock, there is no formal agreement on sharing of information between Canada and Greenland for walrus. SC **recommended** that NAMMCO request the Canadian catch data.

The SC also **recommended** a new survey in the North Water Polyna (NOW; Baffin Bay stock) area as a means of monitoring this population. The SC also **recommends** that new age data and struck and lost data be obtained from both Canada and Greenland.

Satellite tagging of walrus continues in Svalbard, and the researchers are training Russian scientists so that they can use these techniques in the Pechora Sea. Genetics studies on walrus in the Pechora Sea indicate that they are similar to the Svalbard-Franz Josef Land walrus. This would mean that the abundance of the Svalbard-Franz Josef Land walrus population is larger than previously thought.

CETACEANS

Fin whale

The SC agreed with the advice of the Large Whale Assessment WG and **recommended** a catch limit of 146 fin whales for fin whales that can be taken anywhere in the EG+WI (East Greenland + West Iceland) region is safe and precautionary, and that this advice should be considered valid for a maximum of 2 years (2016 and 2017). This is interim advice because the most recent abundance estimate is almost 10 years old. A new abundance estimate is expected from the NASS2015 conducted this past summer.

In addition, this is also an interim advice in accordance with the Council's request necessitated by delays in the IWC RMP *Implementation Review*. This *Review* is scheduled to be completed in June 2016 after which the NAMMCO SC will provide a long-term advice as requested by the Council.

The SC **encouraged** collaborative genetic research led by Iceland aimed at identifying close kin relationships within the North Atlantic and urged member nations to participate by supplying samples.

Humpback whale

The SC agreed with the advice of the Large Whale Assessment WG and **recommended** that the IWC's *Strike Limit Algorithm* (SLA) that has been developed within the Aboriginal Whaling Management Procedure (AWMP) as the best current basis for providing management advice for West Greenland humpback whales. Based on the work of the WG, the SC **endorsed** the advice of 10 strikes per year based on the SLA that was accepted by the IWC. The SC also noted that a higher number may be sustainable because the SLA calculations take into account the Greenlandic *Needs Statement* provided to the IWC of 10 whales.

This advice applies up to and including 2017, and with an expected new abundance estimate from the NASS2015, a new calculation by the IWC SLA to provide advice should be straightforward.

Common minke whale

The SC **endorsed** the advice provided by the WG that a catch limit of 224 common minke whales in the CIC sub-area is safe and precautionary, and that this advice should be considered valid for a maximum of 3 years (2016 – 2018). This is interim advice because the most recent abundance estimate is from 2009, which will then be approaching 10 years old. In addition, this is interim advice due to delays in the IWC RMP implementation review of North Atlantic common minke whales. This review is scheduled to be completed in June 2016 after which the NAMMCO SC will provide a long-term advice as requested by the Council.

New abundance estimates will be developed from the shipboard survey from the results of NASS2015. However, unusually unfavourable weather conditions seriously affected the aerial survey in coastal Icelandic waters and it is clear that the data collected are insufficient for any realistic abundance estimation for the Icelandic continental shelf area (CIC) as a whole. A funding proposal has been submitted for a repeat of this aerial survey in the summer of 2016, and the outcome of this funding request is expected in early 2016.

Beluga and Narwhal

The NAMMCO-JCNB Joint Working Group (JWG) met in Ottawa, Canada, 11-13 March 2015 to update the assessment and advice for belugas and narwhals in Greenland and Canada.

Belugas in West Greenland

The SC **agreed** with the advice and recommendations of the JWG that the total annual removal of beluga in West Greenland is no more than 320 over period from 2016 to 2020.

Narwhals in West Greenland and Canada

A sub-group of the JWG completed their work of developing a catch-allocation model that allows managers to assign catches from the narwhal metapopulation that is shared by Canada and Greenland to the appropriate summering aggregation, by different hunting grounds and seasons. The model includes all information that is available on narwhal movements including telemetry data, all abundance estimates, seasonal occurrence and historical catch data. The NAMMCO SC welcomed this new methodological development for this complex assessment situation. The advancement of the allocation model is considered a step forward and could potentially be applied in many situations where migratory populations are exploited in several areas under various jurisdictions.

The JWG provided an example (see Table 4 in the main report) of the how the catches can be distributed for the period 2015-2020 according to the allocation model.

East Greenland narwhals

The assessments of narwhals in the two stocks in East Greenland (Ittoqqortormiit and Tasiilaq/Kangerlussuaq areas) were updated with recent catch information. The updated assessment estimates a slightly smaller sustainable catch (Table 6 in the main report) than the previous assessment, reflecting that we are further away in time from the available abundance estimate. The total annual removal was estimated to be no more than 50 for the Ittoqqortormiit area and 16 for the Tasiilaq/Kangerlussuaq. The SC **agreed** with the advice of the JWG and noted that the quota for Tasiilaq was recently increased by 10 narwhals above the previous management advice.

Next NAMMCO-JCNB JWG Meeting

Greenland will likely not have any new information to present to the JWG until 2017, and it will be important for the Canadians to provide new abundance estimates and catch history information before the next meeting. From the NAMMCO perspective, the SC recommends waiting until 2017, but recognizes that scheduling a meeting is up to the discretion of the NAMMCO and JCNB Chairs.

Global Review of Monodontids

Prewitt informed the SC that the planning for the NAMMCO organised *Global Review of Monodontids* meeting is continuing. The meeting will be held in conjunction (either immediately before or after) with the Marine Mammals of the Holarctic, which recently announced the location and dates of the meeting: 17-26 October 2016 in Astrakhan, Russia.

Killer whale

At the SC meeting in 2013, the SC noted higher levels of annual catches (19 on average per year from 2010 and 2012) in West Greenland. The SC was then informed that the recent catch statistics on killer whales in West Greenland have not been validated, and at this meeting the SC noted that these catch statistics still have not been validated. The SC **reiterates the recommendation** that all catch data on killer whales are validated before the next SC meeting, so that it is possible for the SC to monitor the development of the hunt.

Pilot whale

The Faroes have developed a scientific monitoring programme to update biological parameters. A number of samples have been collected including samples for ageing, reproductive information, and stomach samples for diet. The plan is to continue to collect samples from every drive and deliver results to the next assessment meeting. The SC commended the Faroes for the work on the sampling programme.

Harbour porpoise

Tagging of harbour porpoises continues in Greenland, and some of the 2014 tags are still operating. Tissue

samples are being collected for various analyses for comparison with previous sampling programs.

In response to the recommendations from the 2013 Harbour Porpoise WG, the Institute of Marine Research (IMR; Norway) is seeking external funding for initiating work on harbour porpoises in cooperation with other research groups.

Sperm whale

A study in Norway using a whale safari company as a platform from which to conduct a photo-identification study of male sperm whales confirmed the presence of both transient and resident male sperm whales in the Bleik Canyon. The results suggest that the sperm whale group(s) found there are a loose feeding aggregation and not a closed population. No trend in the number of sighted whales was found. The estimated size of the feeding aggregation in the Bleik Canyon also fluctuated between years, from 11 to 116 individuals, with no trend evident.

Bowhead whale

A strip-width survey estimated 100 (95% CI: 32-329) bowhead whales in the North East Water Polynya off Northeast Greenland in 2009 (Boertmann et al. 2015). This estimate is considerably higher than observations in the past.

A survey was conducted using a ship and helicopter in Svalbard on the ice-edge for polar bears and ice-associated whales including bowhead whales. The helicopter provided 27 of the 28 bowhead whale sightings.

A tourist vessel also reported a sighting of about 100 whales in the Jan Mayen area and photos confirmed that at least some of the whales were bowheads. A paper from these observations are expected next year.

Blue whale

Iceland reported that they had tagged 2 blue whales during 2014.

An increasing number of blue whales are reported in the waters around Svalbard including in inner parts of the fiord systems especially on the west coast. As reported for fin whales, the Norwegian Polar Institute has started instrumenting animals with satellite tracking devices and collect biopsies for studies of genetics diet and ecotoxicology. In 2015, 3 whales were tagged. Blue whales were also detected on the passive acoustic listening devices that have been deployed at various sites around Svalbard and thus collecting data on the phenology of arrival and departures to the area.

NASS2015

The NASS2015 Steering Committee informed the SC on the three extension surveys that comprised NASS2015, which included an intensive survey with the purpose of estimating the abundance of pilot whales around the Faroe Isles, an aerial survey of the coastal waters in East Greenland and a ship-based survey around Jan Mayen following methods developed for the Norwegian minke whale surveys. All the surveys were successfully completed and resulted in valuable data useful for abundance estimation of the target species.

In addition to these surveys, national surveys covered the West Greenland shelf, areas around Iceland, the Faroes and the Norwegian Sea, providing satisfactory coverage of these waters. With the exception of the Icelandic aerial survey that was hampered by unusually bad weather conditions, all the national surveys were successfully completed and resulted in valuable data useful for abundance estimation of the target species. Details of the survey effort and number of sightings are provided in the report from the Steering Committee (ANNEX 4 of the main report).

The recommendations from the Steering Committee include a plan for the analysis and presentation of the results. It is also recommended that the Steering Committee has now completed its task and that further development of the results from the survey should be transferred to NAMMCO SC and its Abundance Estimation Working Group.

NAMMCO SCIENTIFIC PUBLICATIONS

The current volume, *Volume 11: Age estimation of marine mammals with a focus on monodontids*, is still underway, with a scheduled completion date of early 2016.

The SC discussed possible future volumes. One possibility is to publish a volume with papers from the planned Global Review of Monodontids meeting. Of particular interest are papers from Russian scientists that will present their projects at this meeting. This would be especially helpful because these scientists usually do not publish in English, and therefore their information is usually not accessible.

FUTURE WORK PLANS

Coastal Seals Working Group

The CSWG will meet late February 2016. The likely location is either Copenhagen/Reykjavik/Oslo, to be decided by the Chair in consultation with the Secretariat. The decision will be based on the final participant list. Invited participants (not including SC members) will include 1 person each from the UK, USA, Canada, Sweden and Denmark, and 2-3 Norwegians. (Chair: Kjell Tormod Nilssen)

The WG will mainly address **R-2.4.2** and **R-2.5.2**.

The Terms of Reference for the meeting will be for the WG to:

- 1) assess the status of all populations, particularly using new abundance estimate data that are available from Iceland and Norway.
- 2) address by-catch issues in Norway, Iceland, and the Faroe Islands
- 3) re-evaluate the Norwegian management plans (which have been already implemented) for grey and harbour seals.

The SC **recommended** that all of the available grey seal data from the Faroes is presented to the CSWG for review. The SC **recommends** that the CSWG develops specific plans for monitoring grey seals in the Faroes, e.g., obtaining a relative series of abundance (if a full abundance estimate is not possible at this time).

NAMMCO-JCNB Joint Working Group on Narwhal and Beluga

The Secretariat (Scientific Secretary) will liaise with the JCNB and NAMMCO co-chairs about whether to postpone until 2017. The next meeting (2016 or 2017) will be hosted by Greenland. (Chair: Rod Hobbs, Convenor: Mads Peter Heide-Jørgensen)

ICES/NAFO/NAMMCO WGHARP (Working group on Harp and Hooded Seals)

The WGHARP will meet again in August 2016 at the ICES HQ in Copenhagen, Denmark, to review the status and assess the catch potential of harp and hooded seals in the North Atlantic. Norway has forwarded a request to ICES requesting an assessment of status and harvest potential of the harp seal stocks in the Greenland Sea and the White Sea/Barents Sea, and of the hooded seal stock in the Greenland Sea. This request will form the basis for the next WGHARP meeting. (Chair: Mike Hammill, Convenor: Tore Haug)

By-catch Working Group

The SC recommended convening a one-day meeting of the NAMMCO BYCWG before the CSWG. This WG should include Mikkelsen and Gunnlaugsson from the SC, and Arne Bjørge (Norway), and should incorporate members from outside the marine mammals sphere and the SC (e.g. fishery experts) and outside NAMMCO. (Chair: *to be determined*, Convenor: Geneviève Desportes)

By including external expertise from fisheries and marine mammal science, the WG would

1. Identify all fisheries with potential by-catch of marine mammals
2. Review and evaluate current by-catch estimates for marine mammals in NAMMCO countries.
3. If necessary, provide advice on improved data collection and estimation methods to obtain best estimates of total by-catch over time.

Abundance Estimates Working Group

A small AEWG will be scheduled for May 2016, with only NAMMCO participants. The location will be Copenhagen or Bergen. A second meeting may be scheduled in October 2016, depending on progress with the analyses, and could be held back to back with a LWAWG meeting in October 2016. (Chair: Daniel Pike, Convenor: Geneviève Desportes)

Report of the Scientific Committee

Large Whale Assessment Working Group

A Large Whale Assessment WG may be scheduled before the next SC meeting, after the abundance estimates from NASS2015 are available. The SC recommended inviting Doug Butterworth, but also additional experts to establish additional expertise within the WG, possibly someone from the Butterworth lab. Additional participants (outside of the SC) may include Bjarki Elvarsson and Hiroko Svolvang. (Chair: Lars Walløe, Convenor: Gisli Vikingsson)

Global Review of Monodontids

This workshop will be held in conjunction (either immediately before or after) with the Marine Mammals of the Holarctic, which recently announced the location and dates of the meeting: 17-26 October 2016 in Astrakhan, Russia. (Chair: Arne Bjørge, Organising Committee: Jill Prewitt, Randall Reeves, Robert Suydam, Steve Ferguson, Rikke Hansen, Olga Shpak)

Next SC meeting

The SC suggested that it would be a considerable cost and time saving to have the next SC meeting in Copenhagen rather than Greenland. If the meeting is held in Copenhagen, the SC **urged** all countries to send all of their SC members to the next meeting to take advantage of the cost saving.

ELECTION OF OFFICERS

Tore Haug (Norway) was elected as Chair and Bjarni Mikkelsen (Faroes) was elected as Vice Chair of the SC. The SC **welcomed** the incoming officers and look forward to their terms in office.

MAIN REPORT

1. CHAIRMAN'S WELCOME AND OPENING REMARKS

The Chair of the NAMMCO Scientific Committee (SC), Thorvaldur Gunnlaugsson, welcomed the participants (Appendix 2.) to the meeting. The group welcomed two participants that were new to the NAMMCO SC meetings, Louis A. Pastene from the Institute of Cetacean Research in Japan, and Luis Ridao Cruz from the Faroe Marine Research Institute.

Gunnlaugsson noted the passing of a significant past member of the NAMMCO SC, Dorete Bloch. Dorete passed away on 28 February this year, and her loss was felt by all members of the SC. Dorete was a member of the SC from 1992 to 2009. Geneviève Desportes remembered Dorete as a warm person and quite a character, who welcomed her to the Faroe Islands in 1984. Desportes commended the invaluable input Dorete made to NAMMCO and the Scientific Committee, both scientifically and certainly on the social side. Her open and strong personality meant a lot to the SC.

Bjarni Mikkelsen welcomed the group to the Faroe Islands and especially to the Museum of Natural History. He informed the group on the plans for a trip to see the old whaling station, and on arrangements for a dinner hosted by the Faroe Islands.

2. ADOPTION OF AGENDA

The agenda was adopted with minor revisions (Appendix 1).

3. APPOINTMENT OF RAPPORTEUR

Prewitt (Scientific Secretary) was appointed as rapporteur. The participants were reminded to provide summaries of their presentations, including citations.

4. REVIEW OF AVAILABLE DOCUMENTS AND REPORTS

The list of available documents is available in Appendix 3.

4.1. National Progress Reports

National Progress Reports (NPRs) were received by the member countries (minus catch data from Greenland), and the observers from Canada and Russia. The NPR from Japan was received shortly after the meeting. Information in the NPRs from member countries is presented under the individual agenda items.

Russia

Zabavnikov gave a presentation on Russian research in the Knipovich Polar Research Institute of Marine Fisheries and Oceanography (PINRO), primarily survey activities in the Barents Sea. The plan is for Russian sealing to resume for the White Sea harp seal population in 2016 if ice conditions are favourable.

Japan

This year the SC heard special presentations from Japan on JARPAII and NEWREP-A.

Pastene updated the SC on marine mammal research activities in Japan in 2014-15. Three main research institutions were involved in cetacean research, the National Research Institute of Far Seas Fisheries, the Tokyo University of Marine Science and Technology and the Institute of Cetacean Research. There were 3 main sources of information on cetacean, 1) Whale Research Program under Special Permit in the western North Pacific (JARPNII). Coastal surveys, focused on common minke whales, were carried out in spring and fall in Sanriku and Kushiro regions, respectively. Data and samples for feeding ecology, pollutant, and stock structure studies were collected; an offshore survey, focused on sei and Bryde's whales, was carried in summer. Information for feeding ecology and ecosystem, pollutant and stock structure studies were collected; 2) Dedicated sightings surveys in the North Pacific (summer) and Antarctic Area IV (austral summer 2014/15) by Japan. The formal survey was focused mainly to obtain sighting data for abundance estimation of Bryde's whale while the Antarctic survey was focused mainly on Antarctic minke whale. Photo ID and biopsy sampling

experiments were conducted during these sighting surveys on right, humpback, and blue whales.;3) IWC-POWER sighting survey- in the North Pacific (summer) organized by the IWC SC, focused on sighting, photo-id and biopsy sampling of large whales, particularly Bryde's whale. Other activities involved the update of the DNA registers for large whales based on whales taken by JARPNII and by-catches (setnets, mainly common minke whales but also some few other large whales), and recording strandings. The National Research Institute of Far Seas Fisheries was involved in research of several species of small cetaceans. See details in the Japan NPR.

Pastene and Kitakado presented the research objectives and scientific outputs of the Japanese Whale Research Program in the Antarctic (JARPAII). JARPAII had four objectives, 1) monitoring of the Antarctic ecosystem, 2) modelling competition among whale species, 3) elucidation of temporal and spatial changes in stock structure, and 4) improving the management procedure for Antarctic minke whales. During the presentation, the following outputs of the research were highlighted: i) genetic analyses of samples collected by JARPAII contributed to understand the phylogenetic relationship and taxonomy of minke whales worldwide; ii) two stocks of Antarctic minke whale distribute in the research area and mix spatially in a transition area; iii) several biological parameters, including age-specific mortality rates, were estimated for the Antarctic minke whale on a stock basis; iv) demographic changes occurred in the Antarctic minke whale between the 1940's and 1970's are consistent with the pattern expected under the 'krill surplus hypothesis'; v) nutritional conditions have been deteriorating for Antarctic minke whale since the 1980's, which is coincident with the recovery of other krill-eater large whale species such as humpback and fin whales, after severe exploitation by commercial whaling. It was noted that the attainment of information on krill biomass series in the research area is important for explaining the reasons for the biological changes observed. Pastene noted that his group was interested in cooperating with NAMMCO scientists regarding different aspect of their programs, in particular genetics and satellite tagging.

Kitakado and Pastene presented an outline of the Japanese Research Plan for New Scientific Whale Research Program in the Antarctic Ocean (NEWREP-A). The outline included some explanations on technical aspects of the plan. Japan had terminated its previous whale research program in the Antarctic (JARPAII) following the International Court of Justice (ICJ) Judgment, and subsequently announced the development of a new research program that takes into consideration the objectives of JARPAII (considered reasonable by the Court) and the reasoning and conclusions contained in the Judgment. The NEWREP-A has two main objectives; i) improvement in the precision of biological and ecological information for the application of the RMP to the Antarctic minke whales; and ii) investigation of the structure and dynamics of the Antarctic marine ecosystem through building ecosystem models. Each main objective is composed of several objectives and sub-objectives. The NEWREP-A proposal was submitted to the IWC and reviewed during an Expert Panel Review workshop held in February 2015, and subsequently by the IWC Scientific Committee in June 2015. Several recommendations were offered by the Review Workshop and the Scientific Committee. Japanese scientists have considered all the recommendations, and they have designed a detailed timeline for carrying out the relevant work on these recommendations. Work progress on some recommendations considered of high priority was presented to the meeting.

Discussion

The SC thanked Pastene and Kitakado for their interesting presentations and commended the work being carried out and the results obtained under the JARPA II project. During the following discussion, they were asked whether the same kind of trend studies had been carried out for other species which may also have benefited from the krill surplus, such as several penguins species, crabeater and fur seals. Within JARPA II, there were no analyses that addressed this. It was noted that the focus of the data collection was the Antarctic minke whale and data and samples on the dwarf minke whale were very limited, so it was not possible to see whether that species exhibited the same trends in abundance, life history parameters and body condition. One problem in the modelling exercise was the poor krill trend data in Eastern Antarctica.

For NEWREP-A, the SC thanked Pastene and Kitakado for their presentation of this ambitious and well-founded programme. Pastene explained that main method for age determination would be earplug, but that the project would also examine the possibility a non-lethal technique, the rate of DNA methylation. They also plan to investigate the aspartic racemisation method using eye lenses.

4.2. Working Group (WG) Reports

Reports were available from three working groups in 2015.

4.2.1. Large Whale Assessment

The Large Whale Assessment WG met 5-7 October 2015 in Copenhagen, Denmark and discussed fin whales, common minke whales, and humpback whales. The results from this meeting will be discussed under these individual species' agenda items (8.1, 8.2 and 8.3). The full report is available in ANNEX 1.

4.2.2. NAMMCO-JCNB JWG

The results and recommendations from the NAMMCO–Canada/Greenland Joint Commission on the Conservation and Management of Narwhal and Beluga (JCNB) Joint Scientific WG (JWG) specific to belugas and narwhals were reported under those species' agenda items. The full report is available in ANNEX 2. The new Rules of Procedure for the JCNB-NAMMCO JWG were discussed under Item 5.4.

4.2.3. Survey Planning WG (SPWG)

The SC noted that this Survey Planning WG meeting was a preparation meeting for NASS, and therefore was now outdated. The report full report is available in ANNEX 3. Further discussions of NASS will be taken under agenda Item 9.

5. COOPERATION WITH OTHER ORGANISATIONS

The full observer's reports are available in Appendix 4, and only major points of direct interest are presented below.

5.1. International Whaling Commission (IWC)

Several points regarding cooperation with the IWC were discussed under the relevant species (fin whale: 8.1, humpback whale: 8.2, common minke whale: 8.3 and sei whale: 8.6).

In recent years, there has been movement in IWC SC to change the working procedures of the SC, with more funding allocations to conservation issues rather than management related issues. This movement has gained some support in the Commission. It was noted that this could create further delays completing work relevant to NAMMCO such as *Implementation Reviews* and work in the Aboriginal Whaling Management Procedure (AWMP). Norway has indicated that this delay is not necessarily a problem, which may allow more flexibility to survey on 10 year cycles rather than 6 years. This is not of concern from a conservation perspective and would allow funding to be used for surveys of other species.

5.2. Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)

Desportes drew the attention of the NAMMCO SC to a system of by-catch monitoring using remote electronic video monitoring on ships that observe by-catch as the net is being brought on board. The system is reliable and more and more widely used for monitoring by-catch in European waters. A report of the special Workshop held by ASCOBANS back to back with the AC meeting would become available shortly.

A main area of potential cooperation with ASCOBANS is on the assessment of harbour porpoises, as this is a shared stock with the ASCOBANS area and neither group can make a full assessment without information from the other. Several ASCOBANS participants expressed interest in working with NAMMCO on exploring the idea of convening a joint meeting reviewing the status of harbour porpoises.

5.3. International Council on the Exploration of the Seas (ICES)

Haug reviewed the 2014 and 2015 activities in ICES which have some relevance to the work in NAMMCO SC. This included work in the ICES Working Group on Marine Mammal Ecology (WGMME), the Working Group on Bycatch of Protected Species (WGBYC), and the Joint ICES/NAFO/NAMMCO Working Group on Harp and Hooded Seals (WGHARP). The ICES Annual Science Conference (ASC) generally include sessions with marine mammals included as an integral part, occasionally also sessions entirely devoted to marine mammals.

5.3.1. Joint ICES/NAFO/NAMMCO Working Group Harp and Hooded Seals (WGHARP)

Species-specific information from this working group is presented under the relevant agenda items (7.1 and 7.2).

Report of the Scientific Committee

The SC was informed that ICES and the North Atlantic Fisheries Organization (NAFO) have accepted NAMMCO's request to join the WGHARP. The Secretariat will communicate with the ICES Secretariat before the next WGHARP meeting (scheduled for August 2016) to clarify the procedures in WGHARP, in particular how requests should be forwarded for review. It was noted that a previous request from Greenland to the WGHARP chair was not discussed at the meeting because it had not followed proper procedure. The hope is that NAMMCO can facilitate processes such as this.

5.4. JCNB

The SC reviewed the Rules of Procedure that were agreed by the NAMMCO-JCNB Joint Scientific Working Group, and **agreed** on them as well.

5.5. Arctic Council

Desportes informed the SC that NAMMCO's aim is to become more active within the Arctic Council. Towards this aim, Desportes attended various Arctic Council meetings this year including the Conservation of Arctic Flora and Fauna (CAFF) and Protection of the Arctic Marine Environment (PAME) WGs in September and the CAFF Marine Expert Network Meeting in November. The Marine Expert Network is working on developing a "State of Arctic Marine Ecosystem Report" and NAMMCO is seeking involvement in the development of this report. Fernando Ugarte from the NAMMCO SC also attended this meeting.

5.6. Other

There were no other reports available.

6. ENVIRONMENTAL / ECOSYSTEM ISSUES

6.1. Marine mammals-fisheries interactions (R-1.1.5, 1.1.8)

R-1.1.5 (standing): *The Council encourages scientific work that leads to a better understanding of interactions between marine mammals and commercially exploited marine resources, and requested the Scientific Committee to periodically review and update available knowledge in this field.*

R-1.1.8 (ongoing): *In addressing the standing requests on ecosystem modelling and marine mammal fisheries interaction, the SC is requested to extend the focus to include all areas under NAMMCO jurisdiction. In the light of the distributional shifts seen under T-NASS 2007, the SC should investigate dynamic changes in spatial distribution due to ecosystem changes and functional responses. See also 1.1.6 and 1.4.6.*

Discussion

R-1.1.8 was discussed under agenda item 9.

6.1.1. By-catch

As has been presented previously at the 2013 HPWG and SC meetings, Bjørge et al (2013) estimated that a substantial number of harbour porpoises are being bycaught in Norwegian fisheries. However, it has been recently discovered that recalculations are needed in this analysis due to errors that were found in the data. A new extrapolation will be developed, and the numbers will likely be lower.

Norway is also performing mitigation studies in Lofoten; this work is in progress.

In response to the recommendations from the 2013 Harbour Porpoise WG, the Institute of Marine Research (IMR; Norway) is seeking external funding for initiating work on harbour porpoises in cooperation with other research groups.

The SC also discussed a recent letter from USA to Norway informing them that the USA is implementing rules potentially banning import of marine products from countries with fisheries with high by-catch (gillnets). It was noted that the letter is unclear whether the USA is planning on banning all marine products or just products from the problematic fishery. This is a potentially significant economic issue for all NAMMCO countries, which is another reason for the increased emphasis on future work on harbour porpoises and by-catch in general.

The SC also noted that by-catch is also an issue for coastal seals in Norway. The final by-catch estimations are not yet available but they are believed to be in the 100s of seals. Norway will bring updated estimates next year at Coastal Seals Working Group (CSWG).

Iceland has included by-catch data in the NPR. It was noted that effort in the cod gillnet fishery in 2014 was the lowest on record.

For the Faroes, it is thought that there is usually low levels of by-catch, because of the absence of gillnet fisheries in shallow waters. In 2014 there was one incident in the pelagic mackerel fishery where 15 pilot whales were caught in a trawl. Mikkelsen also reported that single cases have been reported where minke and killer whales were bycaught in pelagic trawl fisheries. Mandatory reporting has been implemented in the Faroes for all vessels above 15 GRT, but not vessels below that size. The SC also noted that fishery effort for mackerel has increased in recent years.

Zabavnikov reported that there is some by-catch of marine mammals from crab fisheries in the Barents Sea, with entanglements of large whales in the gear. Finalised estimates are not yet available, but PINRO plans to organize monitoring effort for next year in the Barents Sea.

6.1.1.1. Update on plans for WG

At last year's meeting, the SC discussed organizing a By-catch WG to look at all by-catch information available in NAMMCO.

The ICES WGBYC (Working Group on By-catch of Protected Species) considers several methods for collecting by-catch data as being reliable, although those have not been implemented at an effort level sufficient to produce reliable data for the assessment of the by-catch pressure in European waters (e.g., ICES 2010ab, 2012). The SC noted that the Norwegian reference fleet method is one of the methods for obtaining by-catch estimates. Others are using observers and remote electronic monitoring.

The SC agreed that the by-catch issue should not be fully handed over to the ICES WGBYC, and that the NAMMCO SC By-catch WG should have an initial meeting soon, then consider a joint meeting with the ICES WGBYC. The NAMMCO SC By-catch WG should include Mikkelsen and Gunnlaugsson from the SC, and Arne Bjørge (from Norway), and should incorporate members from outside the marine mammals sphere and the SC (e.g. fishery experts) and outside NAMMCO.

6.2. Multispecies approaches to management (R- 1.2.1, 1.2.2)

R-1.2.1 (ongoing): *consider whether multispecies models for management purposes can be established for the North Atlantic ecosystems and whether such models could include the marine mammals compartment. If such models and the required data are not available then identify the knowledge lacking for such an enterprise to be beneficial to proper scientific management and suggest scientific projects which would be required for obtaining this knowledge.*

R-1.2.2 (standing): *In relation to the importance of the further development of multispecies approaches to the management of marine resources, the Scientific Committee was requested to monitor stock levels and trends in stocks of all marine mammals in the North Atlantic.*

6.3. Economic aspects of marine mammal-fisheries interactions (New Request- R-1.4.7)

R-1.4.7 (NEW): *The Scientific Committee is requested to review the results of the MAREFRAME ecosystem management project when these become available. In particular, the results should be reviewed with respect to the ongoing and standing requests on marine mammal interactions (R-1.1.0) and multispecies approaches to management (R-1.2.0).*

The European MAREFRAME project includes several components addressing marine mammal fisheries interactions. These include research on interactions between cod and common minke whales in Icelandic waters and between cod and seals off Scotland. The MAREFRAME project is scheduled to be concluded in 2017, after which the SC will review the result as requested by the Council.

6.4. Environmental issues (no active requests)

Barents and Norwegian Seas

Haug and Vikingsson reported from recent research on whales and seals in the North Atlantic: Climate warming may both enhance northward expansion of temperate species from lower latitudes and change the distribution of resident species at higher latitudes. This may present challenges both for newcomers and residents. Cod abundance has increased, and its range has extended northwards in the Barents Sea in recent years. One implication of this is a new overlap of feeding grounds with harp seals and minke whales, two other important top predators in the area. Bogstad et al. (2015) demonstrate that both these mammal species have exhibited declines in body condition in recent years, and competition for food with the increasing cod stock is suggested as a possible explanation. Significant changes in the distribution and abundance of several cetacean species during recent decades has been shown both in Icelandic and adjacent waters (Vikingsson et al. 2015) and in the Norwegian Sea (Nøttestad et al. 2015). Both papers illustrate that whale species have the capability to rapidly perform shifts in distribution and abundance patterns strongly associated with adaptive search behaviour in relation to both changing levels of abundance of their prey and increased sea surface temperatures.

Furthermore, Haug reported on a study based on data from the joint Norwegian-Russian ecosystem surveys in the Barents Sea (Ressler et al. 2015). In comparing acoustic surveys of krill with observed distribution of minke, fin and humpback whales, the authors tested the hypothesis that these animals aggregated where krill were abundant. Fin whale densities were positively and linearly associated with krill abundance, and higher than average densities of humpback whales were found in areas with high krill abundance. No association was found between minke whales and krill. Densities of all 3 whale species were also positively associated with capelin, another target species of the ecosystem surveys. For fin and humpback whales, the effects of capelin and krill on whale densities appeared to be principally separate and additive, although there was some evidence for a stronger effect of krill at low capelin densities. In terms of their preference for krill and capelin, these whale species appeared to be flexible, opportunistic predators.

Changes in Icelandic waters

Vikingsson et al. (2015) was discussed by the SC. During the last two decades, substantial increases in sea temperature and salinity have been reported in Icelandic waters. Concurrently, pronounced changes have occurred in the distribution of several fish species and euphausiids. The distribution and abundance of cetaceans in the Central and Eastern North Atlantic have been monitored regularly since 1987. Significant changes in the distribution and abundance of several cetacean species have occurred in this time period. The abundance of Central North Atlantic humpback and fin whales has increased from around 2,000 to 12,000 and 15,000 to 21,000, respectively, in the period 1987-2007. In contrast, the abundance of minke whales on the Icelandic continental shelf decreased from around 44,000 in 2001 to 20,000 in 2007 and 10,000 in 2009. The increase in fin whale abundance was accompanied by expansion of distribution into the deep waters of the Irminger Sea. In 2014 there was a prominent shift in catch distribution of fin whales compared to all previous years. The distribution of the endangered blue whale has shifted northwards in this period. The habitat selection of fin whales was analysed with respect to physical variables (temperature, depth, salinity) using a generalized additive model, and the results suggest that abundance was influenced by an interaction between the physical variables depth and distance to the 2000m isobaths, but also by sea surface temperature (SST) and sea surface height (SSH). However, environmental data generally act as proxies of other variables, to which the whales respond directly.

Overall, these changes in cetacean distribution and abundance may be a functional feeding response of the cetacean species to physical and biological changes in the marine environment, including decreased abundance of euphausiids, a northward shift in summer distribution of capelin and a crash in the abundance of sand eel. The latter two are suspected to be the primary cause of the recent shift in distribution of common minke whales away from Icelandic coastal waters. Continued monitoring of the distribution and abundance of cetaceans is essential for conservation and management of the cetacean populations and as a part of wider studies of ongoing changes in the ecosystem.

Future work

Haug and Zabavnikov reported that a high priority part of the planned Joint Norwegian-Russian Research Program on Harp Seal Ecology is to deploy satellite transmitters on harp seals in the White Sea. In all the years 2007-2011 it was planned to do this in a joint Russian-Norwegian effort just after the moulting period (in late May), or, alternatively, in late March – early April if ice conditions turns out to be unfavourable in early May. Unfortunately, the Federal Technical Committee (FTC) did not permit satellite tagging using non-Russian tags in Russian waters in all years. In 2012-2015, however, permission to tag harp seals in the White Sea was given

by the Russian Authorities, but a lack of funding (2012-2014) and lack of ice (2015) prevented tagging of seals. In 2016 a new attempt will be made to obtain funding for and carry out satellite tagging in the White Sea. During the tagging experiment, PINRO will provide the necessary logistics required for helicopter- or boat-based live catch of seals in April-May 2016. IMR, Norway will, as before, be responsible for the satellite tags, including providing all necessary technical details, as well as for providing experienced personnel and equipment for anaesthetizing seals and tag deployment. For proper planning and budgeting on both institutes, PINRO scientist must obtain the necessary permissions from Russian authorities before December 2015. The permission from Russian authorities is not dependent on the origin of the transmitters, both UK and Russian transmitters can be used. The transmitters cannot collect geographically positioned temperature and salinity data. After the 2016 tagging season future seal tagging will be decided upon following an evaluation of both the tagging methods and the obtained seal movement data set. Due to low pregnancy rates and decline in pup production it will be important to focus on harp seal ecology and demographics in the coming years.

Discussion

Haug noted that Norway and Russia had planned to tag harp seals this year but ice conditions in the White Sea were not good and they will attempt tagging again in 2016. They have also applied for money to tag harp seals in the Greenland Sea. One main aim of the planned tagging experiments is to explore potential explanations for the observed decreases in blubber thickness, feeding areas and migration routes.

The SC discussed whether any change in female reproductive rates in minke whales had been observed. Øien noted that the data might be available as pregnancies and size of whales are reported by the whalers in the logbook, but age class of whales are not available.

Sandeels used to be main prey item minke whales, and the segment of the population that remains in Iceland is now feeding mainly on gadoids and herring. There is some indication in decrease in body condition for minke whales, but no data is available after 2007. The minke whalers are sampling but the total catch in recent years has been low (about 20) and from a single location near Reykjavik.

6.5. Other (no active requests)

Disturbance Symposium

The Symposium organized by NAMMCO, *Impacts of Human Disturbance on Arctic Marine Mammals, with a focus on narwhal, beluga, and walrus*, was held 13-15 October in Copenhagen. The Symposium was attended by about 45 people and there were 25 presentations on narwhal, belugas, walrus, bowhead whales, harbour seals and humpback whales.

The full report from the Symposium is not available yet, as the time between the Symposium and the SC meeting was short. Prewitt will work on finalising the report with the Chair, Kit Kovacs, and SC Convenor, Mads Peter Heide-Jørgensen, which will be available to Council at the meeting in February, and for the SC to fully discuss at next year's SC meeting. However, Heide-Jørgensen informed the SC about a few key issues of concern.

A mining project – the *Mary River Project* operated by *Baffinland Iron Mines Corp.* – currently under development in the Canadian Arctic attracted special interest at the symposium. The mining will take place on land and is by itself not a concern for the marine environment; however the plan to ship up to 12 million tons of iron ore from Northern Baffin Island to European processing facilities is of concern.

Initial approval was obtained in December 2012 for shipping 18 million tons of iron ore from a port in northern Foxe Basin through Hudson Strait. But due to the high costs of this operation approval was obtained in 2014 for shipping a smaller amount (4.2 mill tons) of iron ore from Milne Inlet on the east coast of Baffin Island through Baffin Bay during the open water season. A new alternative proposal has been prepared involving shipment of 12 million tons iron ore through Eclipse Sound and Baffin Bay for 10 months including winter icebreaking in the Baffin Bay.

The area in Milne Inlet that is planned to be the port of the ore shipping activity is located at one of the most important summering grounds for narwhals. Narwhals are known to be skittish, highly sensitive to human activities and easily disturbed by approaching boats, even in areas without hunting. Studies at the ice edge in Lancaster Sound have demonstrated that narwhals react at long distances to underwater noise from vessels,

with and without icebreaking (Finley et al. 1990). The risk is that the narwhals may abandon the summering ground in Milne Inlet with unpredictable consequences for the population.

Of even larger concern is the prospect of year-round shipping through the heavy pack ice in Baffin Bay. Large numbers of marine mammals rely on the quiet pack-ice environment during winter. Bowhead whales are crossing Baffin Bay both in early winter and in spring where they congregate just outside the entrance to Eclipse Sound, the main shipping area for the iron ore transportation. Belugas also seasonally cross Baffin Bay and in winter they are found in large numbers in West Greenland precisely in the shipping lane. Narwhals from all of the Baffin Bay populations winter in various areas of Baffin Bay over deep water or along the West Greenland where they forage for most of their annual food intake. Shipping in these areas will not only create unprecedented underwater noise in otherwise very quiet environments, but it will also create artificial ice-free channels that may be used by several species of marine mammals with likely detrimental consequences. Among the seals, the ringed seal is perhaps the most abundant species in the pack ice and they are suspected to have a large numbers breeding population in the pack ice.

Other industrial activities that were addressed at the symposium as being particularly important as disturbance factors for marine mammals were seismic exploration in Canada, and West and East Greenland. Migrating narwhals were identified as being particularly sensitive to these activities, but it was also noted that information was missing about safe operational distances to narwhal congregations and how conflicts with narwhal populations could be avoided by areal and seasonal closure of seismic operations.

The SC **draws the attention** of the NAMMCO Council to the potentially severe consequences of these projects. The SC noted that these industrial activities will also likely have impacts on the hunting of these species, and could affect the advice that is given by this SC.

7. SEALS AND WALRUS STOCKS - STATUS AND ADVICE TO THE COUNCIL

7.1. Harp Seal

7.1.1. Review of active requests (R-2.1.4, 2.1.10)

R-2.1.4 (standing): *update the stock status of North Atlantic harp and hooded seals as new information becomes available.*

R-2.1.10 (standing): *provide advice on Total Allowable Catches for the management of harp seals and the establishment of a quota system for the common stocks between Norway and the Russian Federation*

7.1.2. Update

New advice for the White Sea / Barents Sea stock

Haug and Zabavnikov reported from the recent WGHARP meeting (ICES 2014) that PINRO had been assessing the White Sea pup production using multi-spectral aerial surveys since 1998. Surveys flown during 1998-2003 produced pup production estimates that ranged from 287,000 to 340,000. Subsequent surveys indicated a significant reduction in pup production. The reasons for the decline starting in 2004 are not known, although one hypothesis is that there was a decline in fecundity as a result of an increase in percentage of barren females and/or increase in the age of maturity. Results from an aerial survey flown in 2013 gave an estimated pup production of 128,786 (95% CI 98,188 to 159,364).

The population assessment model used for the White Sea/Barents Sea harp seal population provided a poor fit to the pup production survey data. Nevertheless, ICES has decided to continue to use the model which estimated a total 2015 abundance of 1,368,200 (95% C.I. 1,266,300 – 1,509,378). The modelled total population indicates that the abundance decreased from 1946 to the early 1960s, but has generally increased since then. Based on current data availability, the Barents Sea / White Sea harp seal population is considered to be “data poor” (fertility data used in modelling is older than 5 years). The equilibrium catch level is 19 200 1+ animals, or an equivalent number of pups (where one 1+ seal is balanced by 2 pups), in 2015 and subsequent years. The PBR removals are estimated to be 33,500 (14% pups) seals. This catch option indicates a 23% reduction of the 1+ population over the next 15 year period. Despite the fact that this population is now classified as data poor, ICES expressed concerns over the high removals and declining population resulting from the PBR estimations, and concluded that the estimated equilibrium catches were the most preferred option.

Use of drones in pup production surveys

The use of traditional photo aircrafts to assess seal populations in remote areas, such as the West Ice, is expensive, and has also become more difficult to operate during recent years. Haug reported that IMR, with funding from the Norwegian Research Council (NRC), has now started experiments with alternative (and cheaper) methods to perform photo-based aerial surveys of seals in the West Ice. Two research surveys have been carried out to the West Ice, the first in March 2014 using KV *Svalbard*, the second in March 2015 using MS *Bjørkhaug*. The aim of the surveys was to test the usefulness of UAVs (Unmanned Aerial Vehicles), operated by the Northern Research Institute (Norut), to perform aerial photographic surveys of harp and hooded seal whelping patches on the drift ice. Two drones were tested: One small (wingspan 2.10 m) with electromotor and one larger (wingspan 3.80 m) petrol-driven UAV. Digital cameras were used, and the largest UAV was also instrumented with thermal infrared (IR) camera. Both aircrafts were launched by a mechanical launcher from the ship deck. The smaller UAV could be landed on KV *Svalbard*'s helicopter platform, while the larger had to be landed on ice floes, preferably at least 80 m long and 20 m wide. Both UAVs fly along predefined transects and altitudes, but changes can be implemented throughout the flight using satellite-based communication. The UAVs are landed manually. The main aim of the investigations in 2014 was to explore various survey altitudes and camera settings to obtain an optimal altitude and camera set up for photographing seal pups. Simultaneous use of digital and IR cameras enabled exploration of combinations of those to detect and classify seals. Experience obtained from using the UAVs, and the quality of the images taken, were promising. Both harp and hooded seals, including pups, were easily identified on the images taken at an altitude of 300 m (the usual altitude for photographing during traditional surveys). Images from the IR camera did not improve the photo analyses. In 2015, we aimed also to test UV-cameras. Unfortunately, however, the largest UAV (including the equipment) was lost due to technical problems. The experience obtained during the two surveys show that it is necessary to develop a system that enables us to land a relative large UAV on the helicopter platform. The ice conditions in the West Ice seal whelping patches usually implies small and uneven ice floes which make it difficult to land the UAV. It is important to improve the range of the largest UAV. Also, technical improvements on the UAV and equipment are necessary in order to be able to operate in cold and windy conditions.

Manual analysis of images obtained in aerial photographic surveys is extremely time consuming and costly, and involves subjective human interpretation by trained experts. For this reason, the UAV project, also aims at developing methodology for automating the process of counting seals from aerial images. This will be achieved through the development of new image analysis and pattern recognition techniques tailored to detect seals in digital colour images. This part of the work occurs in close cooperation with the Norwegian Computing Center, Oslo.

New population model for harp seals

Haug presented Øigård and Skaug (2015) who had explored a new population model for harp seals. The population model used in current management of the Barents Sea/White Sea harp seal populations is a deterministic age-structured population dynamics model. Available fecundity data are included in the model as a known quantity and no uncertainty around the measurements has been accounted for. The scarce available data on fecundity makes the model stiff and unable to fit to variations in the observed data, and the resulting confidence intervals are likely to be underestimated. Norwegian scientists have suggested an improvement to the population model to make it more flexible in capturing the dynamics of the observed pup production data. They accounted for the temporal variation in fecundity using a state-space approach, and assumed the fecundity to be a stochastic process that was integrated with the age-structured population dynamics of the current management model. Due to the limited availability of fecundity data for the Barents Sea / White Sea population, fecundity information from the Northwest Atlantic harp seal population was used. Summary statistics for the Northwest Atlantic time-series, such as autocorrelation and variance in fecundity, were used as prior distributions in the state-space model. The state-space model was more flexible than the deterministic model and provided a tight fit to the survey pup production estimates as it captured the sudden drop in the survey estimates from 2004 and 2005. The state-space model provided a higher estimate of current population size but also a much higher associated uncertainty. The current management model predicted that the pup abundance will have a slight increase over the next 15 years, whereas the state-space model predicted that the pup abundance will increase substantially. The state-space model show some promising results and might be a step forward towards more realistic modelling of the population dynamics of the Barents Sea/White Sea harp seal population.

Harp seal population identities

Haug reported of a recent paper by Carr et al. (2015) who had studied the phylogeographic structure among the discrete transatlantic breeding areas (the White Sea, Greenland Sea, the Labrador ice Front, and Southern Gulf of St Lawrence) of harp seals. The study was based on phylogenomic analysis of highly-resolved intraspecific phylogenies obtained from complete mitochondrial DNA genomes. Analyses performed indicated that the Greenland Sea population has a markedly younger phylogenetic structure than either the White Sea population or the two Northwest Atlantic populations, which are of intermediate age and homogeneous structure. This is the first study to indicate that the White Sea and Greenland Sea populations have different population genetic histories. The analysis supports the hypothesis that harp seals comprise three genetically distinguishable breeding populations, in the White Sea, Greenland Sea, and Northwest Atlantic.

Impacts of increasing Canadian catches on Greenlandic hunt

The west Atlantic harp seal population is now estimated to be close to 8 million seals and considered to be close to the maximum population size. It is a "data-rich population" and can therefore be managed based upon ecosystem or economic considerations as long as population is above 70% of its present size. Canada had submitted a request to NAFO for WGHARP, in its 2014 meeting, to explore possible management options to reduce the Northwest Atlantic harp seal population. WGHARP examined how different scenarios of reductions of the NW Atlantic population to 5.4 million animals (from the current 7.4 million) over period of 5 or 10 years will affect the abundance of young of the year, juvenile seals and adult seals in Greenland waters and how this might affect the potential number of seals available for the Greenland hunt. To illustrate this, simulations using the NW Atlantic stock assessment model were performed.

The skin industry in Greenland is presently heavily based on young harp seals, especially young of the year (skins from adult seals are not purchased). However, with the planned management options, the Canadians may be allowed to catch close to all pups for a long period and that would exclude Greenland hunters and the Greenland skin industry from this resource.

Greenland had therefore requested the WGHARP to examine how different scenarios of reductions of the population to the N70 level, by Canadian catches, could affect the abundance of young harp seals in Greenland waters.

To answer the request the group first estimated the average number of YOY harp seals that leave the breeding area and thereby potentially can become available to Greenland hunters. The number of pups are reduced by early natural mortality and the Canadian hunt before they leave the breeding area. Taking this into account it was estimated that an average of 449,634 young of the year were leaving the breeding area annually over this 10 year period (2003–2012). This number is an average number of what potentially can be available to the Greenland hunters.

The analysis showed that if the Canadians want to reduce the population to the N70 level over a 10 year period with YOY being 90% of the catch (and if there is a density dependant regulation of the population) it can be done with a catch 900,000 seals for 5 year and 800,000 for the next 5 years. This would reduce the number of YOY for Greenland hunters to zero the first year and the runs give an availability between 18-40% of the 2003-2012 availability for the next nine years. So, a Canadian catch that reduces the population will have significant influence on the availability of YOY by Greenland hunters (and young seals in general), if the catch include a high fraction of pups. If a reduction of the population to N70 is done with YOY only consisting of 50% it will, according to the model, increase the availability of YOY for Greenland hunters. This is because a reduction of adult seals is likely to increase the number of pups born. There might be many harp seals now, but the fraction of the females that gives birth is low, but will increase with a lowering of the adult population.

This means that if sealskin prices increase, Canada can legally start a catch of YOY, which significantly will reduce the availability of young harp seals for Greenland hunters.

Discussion

The SC noted the results from the analysis of the effects of potential increases in Canadian catches on Greenlandic catches, and agreed that although it is unlikely that Canadian catches will increase in the near future, the situation should be monitored.

The SC discussed that the pupping patch that has been observed in south Greenland is likely part of the Greenland Sea population based on the timing of pupping.

7.1.3. Future work

Haug reported that the Joint ICES/NAFO/NAMMCO Working Group on Harp and Hooded Seals will meet again in August 2016 at the ICES HQ in Copenhagen, Denmark, to review the status and assess the catch potential of harp seals in the North Atlantic.

7.2. Hooded seal

7.2.1. Review of active requests (R-2.1.4, 2.1.9)

R-2.1.4 (standing): *update the stock status of North Atlantic harp and hooded seals as new information becomes available.*

R-2.1.9 (ongoing): *investigate possible reasons for the apparent decline of Greenland Sea stock of hooded seals; and assess the status of the stock*

7.2.2. Update

The joint analyses of the Norwegian and Russian data on female hooded seal reproductive biology in the Greenland Sea are currently being prepared for publication.

7.2.3. Future work

Haug reported that the WGHARP will meet again in August 2016 at the ICES HQ in Copenhagen, Denmark, to review the status and assess the catch potential of hooded seals in the North Atlantic.

7.3. Ringed seal

7.3.1. Review of active requests (R-2.3.1, 2.3.2)

R-2.3.1 (ongoing): *stock identity, abundance estimate, etc.*

R-2.3.2 (ongoing): *effects of removals of ringed seals in Greenland*

7.3.2. Update

Greenland

Arctic Ringed seals are presently believed all to be the same subspecies (*Pusa hispida hispida*). Ongoing studies of size differences between ringed seals from different parts of the Arctic show that the ringed seals from the Ilulissat Icefjord (Kangia) in Greenland are significantly larger than other Arctic ringed seals. Ongoing telemetry studies also show that 11 out of 12 seals tagged in this fjord have been stationary (staying in the fjord). These seals also differ from other ringed seals by a somewhat different pelage pattern and significantly deeper dives than other ringed seals. It is possible that they should be regarded as a different subspecies and that they therefore should be managed separately from the other Arctic ringed seals. The plan for 2016 is to investigate possibly genetic differences from other Arctic ringed seals and survey the area for abundance of these seals in the Ilulissat Icefjord. It cannot be ruled out that this kind of ringed seal also exist in other parts of the Arctic.

Discussion

The SC noted that it is important that morphs/ecotypes/subspecies that are so different (and probably highly specialized to certain environmental conditions) are protected from overharvest, because a replacement by the more common ringed seals will be a great loss of diversity. A separate management plan should therefore be developed for the ringed seal in the Ilulissat Icefjord, as soon as a survey has been conducted.

The SC **recommends** that genetics sampling work continues and looks forward to seeing these results. The SC also **recommends** that a survey be conducted to obtain an abundance estimate for this population. The SC noted that with the increasing number of hunters, and with little known about this population, the hunt could have a large impact on the population quickly and Greenland should consider protection of this small population until more information is known. SC **recommends** wider research to look at whether these types of seals are more widely geographically spread.

This work will help towards responding to **R-2.3.1**.

Norway (Svalbard)

Lydersen reported from a newly published article (Hamilton et al 2015) from Svalbard on ringed seal behaviour in relation to changes in the sea ice distribution in the area. Since the first documentation of climate-warming induced declines in Arctic sea-ice, predictions have been made regarding the expected negative consequences for endemic marine mammals. But, several decades later, little hard evidence exists regarding the responses of these animals to the ongoing changes in their environment. Herein, we report the first empirical evidence of a dramatic shift in movement patterns and foraging behaviour of a keystone arctic species, the ringed seal (*Pusa hispida*), before and after a major collapse in sea-ice in Svalbard, Norway, which has shifted the summer position of the marginal ice zone from a position over the continental shelf, northward to the deep Arctic Ocean Basin. Following this change, which is thought to be a “tipping point”, subadult ringed seals swam greater distances, searched more continuously showing less area-restricted search, dove for longer periods, exhibited shorter surface intervals, rested less on the sea-ice and did less sympagic diving during post-moulting foraging excursions. In combination, these behavioural changes suggest increased foraging effort and thus also likely increases in the energetic costs of finding food. Continued declines in sea-ice are likely to result in distributional changes, range reductions and population declines in this keystone arctic species.

7.3.3. Future work

There is continuing work in Greenland (see above).

7.3.3.1. *Possible WG*

In previous SC meetings, the SC suggested that a ringed seal working group could potentially be convened in the next few years, and that the SC should review the CAFF Ringed Seal report from 2014. Desportes reported that the CAFF ringed seal group is currently not active. Norway is the current co-chair of the CAFF Marine WG, and the Norwegian Polar Institute has also proposed research projects together with Americans on ice seals (including ringed seals).

The SC noted that there is still not enough information to warrant convening a NAMMCO Ringed Seal WG and recommends that this should occur after new surveys and genetics studies are completed.

7.4. Grey seal

7.4.1. Review of active requests (R-2.4.2)

R-2.4.2 (*ongoing*): abundance estimates all areas

7.4.2. Update

Norway

Haug informed that the most recent pup production estimate of grey seals in Norway is based on data obtained in 2006-2008. The management plan for coastal seals now implemented in Norway require that data used in assessments should be updated every 5 years. A boat-based visual survey aimed to obtain a new abundance estimate for the species in Norway was, therefore, started in November 2013 (covering the northernmost parts of Norway) and continued in 2014 (covering parts of mid Norway) and 2015 (covering North Norway). Some of the new estimates obtained in mid Norway were much lower than in the previous survey, and quotas were immediately reduced in these areas as a result.

Discussion

The quota that is given in Norway for the Tromsø/Finnmark area is higher than the usual 5% of current abundance estimate for the area because it is assumed that some animals in this area are likely from the Murman Coast. Grey seals are protected in Russia from directed catches, and there is likely no by-catches in Russia because they do not use gillnets.

Faroe Islands

Mikkelsen informed the SC that a reporting system has been implemented in the Faroes to obtain estimates of removals of grey seals in connection with salmon farming. The reportings indicated that the removals are at the level of about 100+ seals per year. The removals mainly occur in November-December and are primarily young animals.

A small amount of by-catch was previously reported in the halibut fishery, however the halibut fishery has now almost stopped.

Some seals tagged seals in Scotland (especially from the northern islands) do come to the Faroes, but they do not stay long.

Discussion

The SC is pleased that the Faroes have developed and implemented this system of reporting. The SC asked about the reliability of the reporting and Mikkelsen said that the Faroes are confident in the reporting. The SC **noted** that removal numbers are high, which is concerning, especially because the population size is unknown.

7.4.3. Future work

Norway

The current surveys, aimed to obtain a new pup production estimate for the entire Norwegian coast, will be completed in 2015. If possible, Russia and Norway will conduct a joint survey of grey seals on the Murman Coast — these grey seal colonies have not been surveyed since 1991.

Faroes

The SC commented that pup counts of grey seals are challenging because they pup in caves, however direct counts at haulout sites, perhaps using drones, should be considered for surveys. These surveys could aim to obtain, at the least, information on relative abundance.

Mikkelsen informed the SC that he would like to continue the tagging study that began in 2007/2008 with 10 tagged animals. He will look into the possibility of cooperation and funding with the aquaculture industry.

Iceland

An abundance estimate from 2012 is available, and there is a plan for a new grey seal survey in 2016 pending funding.

7.4.3.1. Coastal Seals WG (CSWG)

The CSWG (Chair: Kjell Tormod Nilssen) will meet in early March 2016. The WG will mainly address R-2.4.2 and R-2.5.2.

By February 2016, the CSWG will likely have by-catch estimates and a new complete grey seal estimate in Norway for consideration at the meeting.

The Terms of Reference for the meeting of the WG are:

- 1) assess the status of all populations, particularly using new abundance estimate data that are available from Iceland and Norway.
- 2) address by-catch issues in Norway, Iceland, and the Faroe Islands
- 3) re-evaluate the Norwegian management plans (which have been already implemented) for grey and harbour seals.

The SC **recommended** that all of the available grey seal data from the Faroes is presented to the CSWG for review. The SC **recommends** that the CSWG develops specific plans for monitoring grey seals in the Faroes, e.g., obtaining a relative series of abundance (if a full abundance estimate is not possible at this time).

The 2015 abundance estimates from Norway will be available at CSWG. The Norwegian by-catch data is being worked on currently and they hope to have the data validated in time for the CSWG.

7.5. Harbour seal

7.5.1. Review of active requests (R-2.5.2)

R-2.5.2: conduct a formal assessment of the status of harbour seals around Iceland and Norway as soon as feasible

7.5.2. Update

Norway

Haug reported that aerial and boat based visual surveys aimed to obtain a new abundance estimate for harbour seals in Norway were started in 2011 and continued in 2012-2015. This has yielded a new point estimate of

7,594 for the species for the entire Norwegian coast. This new estimate is implemented in current management of the species – this management now follows the management plan reviewed by NAMMCO SC in 2011.

IMR, in collaboration with the Swedish Natural History Museum, are considering tagging harbour seals in Sweden to see if they visit Norwegian coast.

Iceland

Results from the partial survey of harbour seals in 2014 shows an appreciable decrease in abundance in the most important haul-out areas. Aerial surveys of harbour seals are planned for 2016, if funds are available.

Greenland

In Greenland a new small group of harbour seals (three mothers with pups) was documented. Only four regularly used haul-out places (with a total of less than 100 seals) is presently known in Greenland. All hunting on this species was banned in 2010 and it is believed that several small remnant populations still exist, but live undetected.

Discussion

Norwegian catch is reported by hunters and is considered reliable. The quotas are precautionary so some underreporting is not considered problematic.

In Iceland, the large uncertainties in abundance and catch statistics, both direct catches and by-catches, make assessments of the present status and sustainability of removals problematic. Hence, in its advice to the government in 2015 the Marine Research Institute (MRI) declared that in the absence of new abundance estimates it was unable to evaluate whether the existing management objectives of grey seals and harbour seals are being met.

7.5.2.1. Presentation from Japan

Kitakado updated his on-going works on risk-assessment for the Kuril harbour seals in Japan and reported the current discussion process for conservation and management. The population of Kuril harbour seals off Cape Erimo in northern Japan had dramatically declined by the 1970s due to overhunting, and it had once faced with a risk of extinction. Since then, owing to protection measures, the population size has shown a steady recovery while the damage to set net fishery by the seals has also increased. Conservation of the population should of course be prioritized, but it is also necessary to develop a resource management strategy focused to achieve a balanced objective between the conservation of population and mitigation of the damage to the fishery. For this purpose, assessment works were required to know the carrying capacity and the current level of depletion of the population. Fortunately, surveys of the harbour seal population have been continuously conducted during both the breeding and moulting seasons, over a long period. Based on the observations for population indices as well as partial information on the extent of past by-catch, density-dependent age-structured production models were constructed and then the parameters were estimated through maximizing a joint likelihood function from multiple series of observations. In addition, simulation studies were conducted to evaluate possible management procedures for the population. Results of the maximum likelihood estimation showed that the models used in the analyses fitted well to the data. As the estimation result, it was found that the population level has exceeded at least 60% of the carrying capacity though the extent of recovery slightly depends on the model assumption. Regarding the future projection in the simulation study under the assumption of a stochastic stock-recruitment relationship, the population size will still increase at the rate of current level of by-catch. Also, results of risk-assessment showed that the extinction risk of the population is negligibly small unless high mass mortality events frequently happen. Given these results, the Ministry of Environment in Japan decided to remove the population from the “Threatened Category” and will develop some interim approaches, possibly including culling of animals to achieve the balance objective for the conservation and management of the Kuril harbour seals off Cape Erimo. At this moment, some simulation results showed that some future management procedures involving culling adults while avoiding unintentional by-catch of yearling animals would be effective.

The SC thanked Kitakado for this interesting presentation. In discussion the SC noted the promising and interesting use of the infrared camera for counting seals.

7.5.3. Future work

Haug reported that biopsy sampling of tissue from pups for genetic studies had been carried out on the Norwegian coast in recent years, and that genetic studies were now in progress. The aim of such studies is to assess the population structure of the species using DNA analyses.

7.5.3.1. *Coastal Seals WG*

As discussed above, the CSWG (Chair: Kjell Tormod Nilssen) will meet in early March 2016. The WG will mainly address R-2.4.2 and R-2.5.2.

By February 2016, the CSWG will likely have by-catch estimates and a new complete grey seal estimate in Norway for consideration at the meeting.

The Terms of Reference for the meeting will be for the WG to:

- 1) assess the status of all populations, particularly using new abundance estimate data that are available from Iceland and Norway.
- 2) address by-catch issues in Norway, Iceland, and the Faroe Islands
- 3) re-evaluate the Norwegian management plans (which have been already implemented) for grey and harbour seals.

The SC also recommended additional work for grey seals to be completed by the WG (see item 7.4.3.1).

7.6. Bearded seal

7.6.1. Update

No current work was reported.

7.6.2. Future work

No future work was noted.

7.7. Walrus

7.7.1. Review of active requests (R-2.6.3)

R-2.6.3 (ongoing): *effects of human disturbance, including fishing and shipping activities, in particular scallop fishing, on the distribution, behaviour and conservation status of walrus in West Greenland.*

7.7.2. Disturbance Symposium

A preliminary discussion on the results from the Symposium were discussed under item 6.5. The final report will be available to the SC for discussion at next year's meeting.

7.7.3. Assessment Baffin Bay

Stock structure

The Greenland Institute of Natural Resources (GINR) continued the tagging of walrus in the Qaanaaq area (Baffin Bay stock) in 2015. Open water early in the season allowed for transportation to the Wolstenholme Fjord where large numbers of walrus have been detected during aerial surveys. No tagging has been attempted before in this area due to difficult logistical conditions after closure of the hamlet of Moriussaq. A total of 21 walrus were tagged with satellite transmitters in June 2015 in a collaboration with local hunters from Qaanaaq. The tracking of the walrus showed that they left the Wolstenholme Fjord during June and moved west across the North Water to the east coast of Ellesmere Island. Some walrus moved north along Ellesmere Island, some went far west into Jones Sound and 3 walrus went south of Devon Island into Lancaster Sound where they headed west to Cornwallis Island.

These new tracking data confirm that the Baffin Bay population of walrus extend far west into the Canadian high Arctic.

Abundance

The importance of the North Water polynya in Smith Sound as an overwintering area for marine mammals has been questioned. One way to address the issue is to assess the abundance of selected marine mammals that are present during winter in the North Water. Visual aerial surveys involving double observer platforms were

conducted over the eastern part of the North Water polynya in April 2014. Four species of marine mammals were included in strip census estimation of abundance. Perception bias was addressed using a double-platform survey protocol, a Chapman mark-recapture estimator for whales, seals and walrus on ice, and a Mark Recapture Distance Sampling estimation technique for walrus in water. Availability bias was addressed by correcting abundance estimates by the percentage of time animals detected in water were available for detection at the surface. The resulting estimates suggested that 2,544 walrus (95% CI 1,513–4,279) wintered in the eastern part of the North Water polynya in April 2014. The walrus estimate is larger than previous summer estimates and it emphasizes the importance of the habitat along the Greenland coast as a walrus wintering ground.

Discussion of the SC

The SC **adopted** this abundance estimate for use in the updated assessment.

Catch Statistics

SC/22/18 presents data on the catch of walrus for the Baffin Bay population. Since 2007, when quotas were introduced in Greenland, catches of walrus have been reduced considerably. Throughout the years, more males than females have been caught. October is the month when most walrus are caught with almost 1/3 (32%) of total catches from the years 1993–2014. The Baffin Bay population is also harvested in the Canadian High Arctic and it is recommended that catches from these areas are included in the catch history.

In this catch history, catches from Upernavik were separated out from the Baffin Bay stock.

Discussion of the SC

The catches in this paper are not corrected for struck and lost. The SC **reiterated the previous recommendation** that Greenland provide information on struck and lost in walrus.

The SC **noted** that in Greenland there are 2 different reporting schemes for quota versus no-quota animals (*Piniarneq* and *Særmeldingsskema*). There are inconsistencies between the numbers that are reported, which creates problems when attempting to determine which numbers are accurate. For any assessment, the SC noted that it is important to obtain accurate removals. It is important to know whether the smaller numbers in *Piniarneq* reflects a general underreporting for all species in this system, as some marine mammal species are only reported under this system. The SC therefore **recommended** that Greenland should streamline their reporting system, and also conduct a study to investigate why the numbers are different between the reporting schemes.

There are Canadian catches included for up until 2011. The SC **noted** that although this is a shared stock, there is no formal agreement on sharing of information between Canada and Greenland for walrus.

Assessment

SC/22/16 used the new abundance estimate and the updated catch history to update the assessment for Baffin Bay walrus. It used the Bayesian model that has been used by NAMMCO WGs in past assessments of walrus, beluga and narwhal, with the prior distributions on the biological parameters being those of the 2013 assessment of walrus.

Estimates of animals that were struck and loss were added to the catch history of landed catches. A field study in the area in 1977/78 estimated loss rates between 15% and 25% from 34 hunts with a total of 112 landed animals (Born and Kristensen 1981), and more recent estimates by hunters indicate much lower loss rates of no more than five percent (APNN 2014; Born unpublished). The assessment used the span of these estimates as a uniform prior from a low catch history with a loss rate of 5%, to a high catch history with a loss rate of 25%. The sex ratio in the major part of the catch history was assumed to be even, except for catches after 2007 where gender identification by hunters estimated an average fraction of 34% females.

The analysis included also age estimates for 376 animals that were landed in Qaanaaq from 1987 to 1991. The fit of models to the age data showed an under-representation of animals younger than ten years, in agreement with a hunt that takes mainly adult animals.

The magnitude of the decline in the Baffin Bay stock caused by historical catches is unclear due to incomplete catch reporting, but four different models showed an initial decline until around 2005, and an increasing population thereafter, reflecting a decline in the annual landed catches from about 150 from 1999 to 2003, to about 80 from 2004 to 2008.

An exponential model estimated a stock that declined from 3,120 (90% CI: 2,640-3,730) animals in 1960, to 1,410 (90% CI: 1,220-1,670) in 2006, and then increased to 1,820 (90% CI: 1,420-2,330) in 2015. The models that were fitted to the age data showed a relatively precise estimate of the annual growth rate to about 7.9% (90% CI: 6.5-9.3%), while an exponential model with no age data had a much less precise estimate of the growth rate (7.1%; 90% CI: 3.9-10%).

While there are no reasons to question the growth rate estimate from the age data, the SC noted that these data are almost 30 years old, and the growth may thus no longer apply. It was therefore decided to use the exponential model with no age data for the management advice. This model that relied only on the trend in the three estimates of spring abundance from 2009 to 2014, provided a better reflection of the uncertainty on the present growth in the population.

The SC noted also that the Greenlandic quota for the area is given in terms of landed animals, assuming a loss rate of no more than 3%. But with the upper end of the loss rate in the assessment being based on data from the area, the SC found that an assumed loss rate of 3% was unrealistically low. It was therefore decided to give the advice in terms of landed animals with the point estimate of the loss rate (14.4%) from the assessment subtracted from the total removal. This provides the estimated trade-off in Table 1 between the annual landed catches and the probability of an increase in the population from 2016 to 2020, with an annual catch of 92 walrus being recommended as the maximum take that will allow a 70% chance of increase during this time period.

The recommended annual take of 92 walrus includes the Canadian catches in the high arctic. With the average annual take in three locations in Canada (Grise Fjord, Craig Harbour and Resolute Bay) being seven from 2007 to 2011, and the SC therefore **recommended** that no more than 85 walrus are landed annually in Qaanaaq from 2016 to 2020.

Table 1: The estimated probabilities of increase in the Baffin Bay stock of walrus from 2016 to 2020 given a range of annual landed catches (total landings in Qaanaaq and the Canadian High Arctic).

Probability	0.70	0.75	0.80	0.85	0.90	0.95
Catch	92	86	80	73	66	57

Discussion of SC

SC **recommended** that NAMMCO request the Canadian catch data. The SC also **recommended** a new survey in the North Water Polyna (NOW; Baffin Bay stock) area as a means of monitoring this population. The SC also **recommends** that new age data and struck and lost data be obtained from both Canada and Greenland.

7.7.4. Update

The SC **noted** that the abandoned village in Greenland used as a field camp in the tagging study (Moriussaq) did not have many walrus present when it was habited. However, after it was abandoned, walrus are moving into the area, suggesting that the presence of humans affects walrus distribution.

Lydersen presented information on tagging walrus in Svalbard. Their research group have also trained Russian researchers on their tagging techniques and they conducted similar tagging work in the Pechora Sea.

Genetics studies on walrus in the Pechora Sea indicate that they are similar to the Svalbard-Franz Josef Land walrus. This would mean that the abundance of the Svalbard-Franz Josef Land walrus population is larger than previously thought.

8. CETACEANS STOCKS - STATUS AND ADVICE TO THE COUNCIL

8.1. Fin whale

8.1.1. Review of active requests (R-3.1.7, 1.7.11, 1.7.12)

R-1.7.11 (ongoing): *develop estimates of abundance and trends as soon as possible*

R-1.7.12 (ongoing): *Greenland requests the SC to give information on sustainable yield based on new abundance estimates expected from NASS2015 for all large baleen whales in West Greenland waters*

R-3.1.7 amended (ongoing): *complete an assessment of fin whales in the North Atlantic and also to include an estimation of sustainable catch levels in the Central North Atlantic. NEW AMENDMENT:* “While long-term advice based on the outcome of the RMP Implementation Reviews (with 0.60 tuning level) is desirable, shorter term, interim advice may be necessary, depending on the progress within the IWC. This work should be completed before the annual meeting of the SC in 2015.”

8.1.2. Large Whale Assessment WG (see ANNEX 1)

In 2008 the NAMMCO SC was requested to complete an assessment of fin whales in the North Atlantic, and also to include an estimation of sustainable catch levels in the Central North Atlantic. In 2014 the Council endorsed an amendment to the request to include the following additional text: “While long-term advice based on the outcome of the RMP *Implementation Reviews* (with 0.60 tuning level) is desirable, shorter term, interim advice may be necessary, depending on the progress within the IWC. This work should be completed before the annual meeting of the SC in 2015.”

The relevant areas for the current management advice are EG (East Greenland) and WI (West Iceland), since all Icelandic whaling for fin whales takes place in these areas. The WG received in its meeting results from calculations based on the IWC RMP with 0.60 tuning, and which provides catch limits for North Atlantic fin whaling in these areas. Based on these calculations the WG **recommends** that a catch limit of 146 fin whales for fin whales that can be taken anywhere in the EG+WI region is safe and precautionary, and that this advice should be considered valid for a maximum of 2 years (2016 and 2017). This is interim advice because the most recent abundance estimate is from 2007, and the WG reiterated its previous recommendation that 10 years was the longest period the approach applied could be used without a new abundance estimate becoming available. The WG also recognized that a survey had been carried out this past summer (2015), and by this time next year a further agreed abundance estimate should be available.

The IWC *Implementation Simulation Trials* for North Atlantic fin whales are ongoing and an IWC workshop has been tentatively scheduled for February 2016 to complete these trials. Completion of the IWC’s work will be informative for long-term advice; however the WG recognizes that this IWC work has been postponed in the past, and issues may yet arise that again delay completion of this work.

Discussion

The SC **agreed** with the conclusions of the WG that a catch limit of 146 fin whales for fin whales that can be taken anywhere in the EG+WI region is safe and precautionary, and that this advice should be considered valid for a maximum of 2 years (2016 and 2017).

In addition to the abundance estimate being close to 10 years old, this is also an interim advice in accordance with the Council’s request due to delays in the IWC RMP *Implementation Review* of North Atlantic fin whales. This review is scheduled to be completed in June 2016 after which the NAMMCO SC will provide a long-term advice as requested by the Council.

8.1.3. Update

Lydersen reported from a new program on fin and blue whales in the Svalbard area, which involved satellite tracking and collection of biopsies for studies of genetics, diet, and ecotoxicology.

8.1.4. Future work

The SC **encouraged** collaborative genetic research led by Iceland aimed at identifying close kin relationships within the North Atlantic and urged member nations to participate by supplying samples.

8.2. Humpback whale

8.2.1. Review of active requests (R-3.2.4, 1.7.12)

R-1.7.12 (ongoing): *Greenland requests the SC to give information on sustainable yield based on new abundance estimates expected from NASS2015 for all large baleen whales in West Greenland waters*

R-3.2.4 (ongoing): *conduct a formal assessment following the completion of the T-NASS...In addition the Scientific Committee is requested to investigate the relationship between the humpback whales summering in West Greenland and other areas and incorporate this knowledge into their estimate of sustainable yields of West Greenland humpback whales.*

8.2.2. Update

Large Whale Assessment WG (see ANNEX 1)

The NAMMCO SC last reviewed the status of the West Greenland humpback whales in 2010. At that time, the SC applied the “interim SLA” to the most recent abundance estimate from 2007 to conclude that an annual catch of 20 whales was safe, and that this level of catch would allow the population to increase. Management advice for humpback whales off West Greenland has been provided by the IWC SC, which agreed on a final AWMP SLA for this stock in 2014. The NAMMCO WG endorsed this SLA as the best current basis for providing management advice for West Greenland humpback whales, as well as the current advice of up to 10 strikes per year requested by Greenland (within the IWC system) as being safe. The WG discussed but did not come to a conclusion on whether NAMMCO should consider the impact that the IWC’s *Needs Statement* has on the quotas given by the SLA, considering that it is a component of the SLA procedure.

This advice applies up to and including 2017, and with an expected new abundance estimate from the NASS2015, a new calculation by the IWC SLA to provide advice should be straightforward.

Discussion of the SC

Based on the work of the WG, the SC **endorsed** the advice of 10 strikes per year based on the SLA that was accepted by the IWC, and noted that a higher number may be sustainable.

The SC noted that **R-1.7.12** was not considered yet as the abundance estimate from NASS2015 is not yet available.

Satellite Tagging in Iceland

Víkingsson presented a summary of satellite tagging of humpback whales by the MRI. Since 2007, 21 humpback whales have been instrumented with satellite tags in Icelandic waters. These experiments have revealed local movements in Icelandic coastal waters and information on migration patterns during autumn and winter. Five humpback whales were tracked southwards out of Icelandic waters. One of these started migration in late November and the other four in January and February. Four of these tracks represent only partial migration routes. However, in 2014/2015 the migration of one humpback whale was followed between North Icelandic waters and Silver Bank off the coast of the Dominican Republic. This is the first documentation of a complete migration track of a baleen whale between feeding and breeding grounds in the North Atlantic.

The SC complemented Víkingsson on this work.

8.2.3. Future work

A new humpback whale abundance estimate is expected for Greenland from the NASS2015.

8.3. Minke whale

8.3.1. Review of active requests (R-3.3.4, 1.7.11, 1.7.12)

R-1.7.11 (ongoing): *develop estimates of abundance and trends as soon as possible*

R-1.7.12 (ongoing): *Greenland requests the SC to give information on sustainable yield based on new abundance estimates expected from NASS2015 for all large baleen whales in West Greenland waters*

R-3.3.4 amended(ongoing): *full assessment, including long-term sustainability of catches, of common minke whales in the Central North Atlantic... assess the short-term (2-5 year) effects of the following total annual catches: 0, 100, 200 and 400*

8.3.2. Update

Large Whale Assessment Working Group (see ANNEX 1)

At NAMMCO/23, Council adopted an amendment to **R-3.3.4**: “The SC is requested to complete assessments of common minke whales in the North Atlantic and include estimation of sustainable catch levels in the Central North Atlantic. While long-term advice based on the outcome of the RMP *Implementation Reviews* (with 0.60 tuning levels) is desirable, a shorter-term, interim advice may be necessary, depending on the progress within the IWC. This work should be completed before the annual meeting of the SC in 2015.”

The IWC *Implementation Review* is not formally completed, but both the stock structure and the abundances in the central and north-east Atlantic were agreed in the IWC SC meeting in 2014. The genetic work suggests a single oceanwide stock with incomplete mixing. In a management context in the IWC SC it has been decided to operate with three stocks at a *Medium Area* level, i.e., a Western (W), Central (C) and Eastern (E) stock (Fig. 1). The IWC SC also decided to merge many of the *Small Areas* within each of these *Medium Areas*. The NAMMCO WG endorses the single-stock hypothesis and the use of the W, C and E Management Areas in the future.

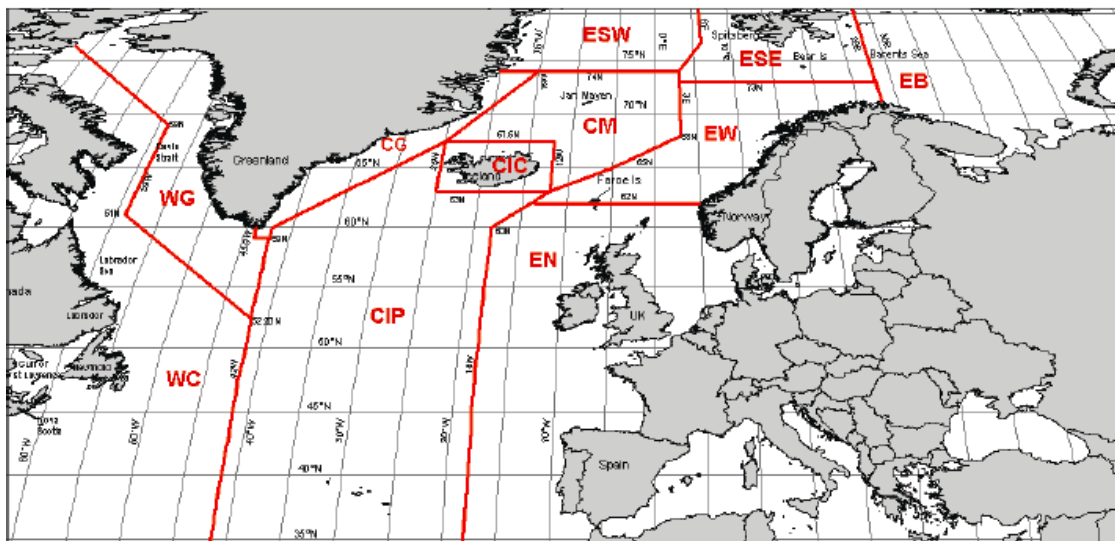


Fig. 1. Map of the North Atlantic showing the *sub-areas* defined for the North Atlantic common minke whales.

However, for the present assessment and interim management advice the WG have decided to give separate advice for the CIC (Iceland coast), CM (Jan Mayen), and CG (East Greenland) IWC *Small Areas*. The main reasons for this decision are that different information on abundance is available for each of these *Small Areas*, and that each supports a separate whaling operation. Icelandic minke whaling takes place in the CIC, Greenlandic minke whaling off East Greenland takes place in CG, and some Norwegian whaling for minke whales previously used to take place in CM.

The WG considered that the existing results from the IWC *Implementation Simulation Trials* provide an up-to-date and reasonably robust indication of the current status of common minke whales in the North Atlantic. The results indicate that these populations have either:

- i) never been substantially reduced below their pre-exploitation levels, or
- ii) been earlier reduced by no more than about 50%, but recently have been increasing.

Hence these assessments do not indicate any reason for concern about the status of common any reason for concern about the status of common minke whales in the North Atlantic.

Management advice

West “Medium area”

The current IWC management advice for West Greenland common minke whales (164 per year) is based on the interim AWP procedure applied to the 2007 estimate of 16,100 (CV: 0.43) common minke whales off West Greenland. The IWC advice for the next block quota starting in 2018 is planned to be based a

management procedure that has not yet been established, but is planned to be developed from the trial structure of the ongoing RMP *Implementation Review*.

Central “Medium Area”

The NAMMCO SC previously agreed that implementation of the IWC RMP to calculate catch limits provided an appropriate basis to address the Council’s requests for assessments and advice. This year the WG received calculations for the CIC *Small Area*, based on the RMP CLA with tuning level of 0.60. Based on these results the WG recommended that a catch limit of 224 common minke whales in the CIC *sub-area* is safe and precautionary, and that this advice should be considered valid for a maximum of 3 years (2016 – 2018). This is interim advice because the most recent abundance estimate is from 2009, and the WG reiterated its previous recommendation that 10 years is the longest period the approach applied could be used without a new abundance estimate becoming available. The WG would prefer to apply the CLA to the whole Central *Medium Area*, but the most recent abundance survey was that in 2009 which covered only the CIC *sub-area*. To apply the RMP at the *Medium Area* level would mean that the most recent abundance estimate for that whole region is from 2007, and so already almost 10 years old.

It should be noted that the catches in the CIC *sub-area* have in recent years been a small fraction of the total allowable catch, and although catch limits have been allocated to the CM *Small Area* using the IWC RMP with 0.60 tuning, no whales have been taken there in recent years (since 2011).

The management advice for East Greenland has been developed in the IWC SC standing WG on the AWMP.

The WG noted that a new abundance estimate is needed for the whole Central *Medium Area*.

East “Medium Area”

For the IWC East *Medium Area* the IWC-SC agreed the abundance estimates (mid time point 2011) in 2014, and agreed that the genetic data showed that all common minke whales in this *Medium Area* could be regarded as belonging to one stock. For precautionary reasons the IWC-SC agreed that the EN *Small Area* should continue to be regarded as a *Small Area*, but that the *Small Areas* EW, EB and ES should be combined in a new *Small Area*. The IWC-SC *Implementation Simulation Trials* for the North Atlantic Central and East *Medium Areas* showed acceptable performance for this structure. For these reasons management advice for common minke whales in the next six year period from 2016 for the East *Medium Area* should be based on the 2011 abundance estimates using RMP with tuning level 0.60 and with *catch cascading* between the two remaining *sub-areas*.

Discussion

The SC **agreed** with conclusions and **endorsed** the advice provided by the WG that a catch limit of 224 common minke whales in the CIC *sub-area* is safe and precautionary, and that this advice should be considered valid for a maximum of 3 years (2016 – 2018). In addition to the abundance estimate being close to 10 years old, the advice provided for the Icelandic minke whale operation is interim in accordance with the Council’s request necessitated by delays in the IWC RMP implementation review of North Atlantic common minke whales. This review is scheduled to be completed in June 2016 after which the NAMMCO SC will provide a long-term advice as requested by the Council.

The SC noted that since the resumption of commercial whaling in 2006, catches have been much lower than the issued quota levels. While the size of the domestic market is likely the largest causative factor, unusually low catches in the most recent years is mainly due to a combination of low densities of common minke whales off southwest Iceland, unfavourable weather conditions and logistical constraints for distance from whaling grounds to the single processing plant.

8.3.3. Future work

New abundance estimates will be developed from the shipboard survey from the results of NASS2015. However, unusually unfavourable weather conditions seriously affected the aerial survey in coastal Icelandic waters. Thus, only 37% of the planned survey coverage was realized, the lowest of the 6 surveys attempted since 1987. The realized survey effort was almost confined to the western and southern parts of the survey area. Therefore, it is clear that the data collected are insufficient for any realistic abundance estimation for the

Icelandic continental shelf area (CIC) as a whole. A funding proposal has been submitted for a repeat of this aerial survey in the summer of 2016. The outcome of this funding request is expected in early 2016.

8.4. Beluga

8.4.1. Review of active requests (R-3.4.9, 3.4.11)

R-3.4.9 (ongoing): *provide advice on the effects of human disturbance, including noise and shipping activities, on the distribution, behaviour and conservation status of belugas, particularly in West Greenland; narwhal added at NAMMCO 22*

R-3.4.11 (standing): *update the assessment of both narwhal and beluga*

8.4.2. JCNB/NAMMCO WG report

The JCNB/NAMMCO Joint WG (JWG) met in Ottawa, Canada, 11-13 March 2015 (ANNEX 2).

Catches

The historical catches of beluga in West Greenland from 1954 to 1998 were updated for underreporting and animals struck and lost, with the estimated total historical takes being on average 28% larger than the reported catches. All catches are assumed taken from the Somerset Island summering stock and all the catches in West Greenland are presumably taken from the fraction of that stock that winters in West Greenland. The exception is the winter catches in Qaanaaq (approx. 5% of annual catches in Qaanaaq) that likely are taken from the fraction that winter in the North Water. It is unknown which stock is supplying the summer hunt in Qaanaaq (approx. 15% of annual catches in Qaanaaq). A few confirmed catches (and sightings) of belugas have been recently been report from East Greenland.

In 2013 there were higher catches than usual in Upernavik. The reason for this is not known, but one potential cause could be seismic activities in 2013. Seismic activities could have driven the whales closer to shore, making them more susceptible to hunting. It is known that belugas are easily scared into the coast, and also that the migration patterns of belugas are potentially affected by seismic activities.

Under-reporting of catches remains a potential problem, and this is problematic as no straightforward correction is possible.

Abundance

The JWG agreed on a new abundance estimate of 9,072 (CV=0.32, CI: 4,895-16,450) beluga off West Greenland in March-April 2012.

The largest abundance of whales was found at the northern part of Store Hellefiske Bank, at the eastern edge of the Baffin Bay pack ice, a pattern similar to that found in nine systematic surveys conducted since 1981. A clear relationship between decreasing sea-ice cover and increasing offshore distance of beluga sightings was established from all previous surveys, suggesting that belugas expand their distribution westward as new open water areas on the banks of West Greenland open up earlier in spring with reduced sea-ice coverage or early annual ice recession.

Assessment update

The assessment of the winter aggregation off West Greenland was updated with the new abundance estimate and the updated catch history. It estimated a decline (Fig. 2) from 19,140 (90% CI:12,680-28,260) individuals in 1970 to a maximal depletion of 8,130 (90% CI:5,740-11,440) in 2004, and an increase to 11,420 (90% CI:6,370-17,850) in 2020 (assuming yearly post 2014 catches of 294). The predicted change from a declining to an increasing population was caused by the introduction of quotas in Greenland, with annual catches in the order of 500 to 700 reduced to less than 200 after 2004.

Advice

Reiteration of Past Advice

The JWG **reiterated** the previous advice from 2005 and 2012 about seasonal closures. The following seasonal closures are **recommended**:

- Northern (Uummannaq, Upernavik and Qaanaaq): June through August

- Central (Disko Bay): June through October
- Southern (South of Kangaatsiaq): May through October.
- For the area south of 65°N, it is recommended that no harvesting of beluga be allowed at any time.

The function of these closures is to protect the few animals that may remain from historical summer aggregations in Greenland, and to allow for the possibility of reestablishment of the aggregations.

No specific advice was given on the North Water, noting that the removals remain at a low level relative to the population size derived from the 2009-2010 and 2014 surveys in the North Water and around Somerset Island in 1996, and assuming that future catches remain at low levels.

New Advice

With the new abundance estimate for 2012, the JWG **recommends** that the total annual removal of beluga in West Greenland in no more than 320 over period from 2016 to 2020 (Table 2).

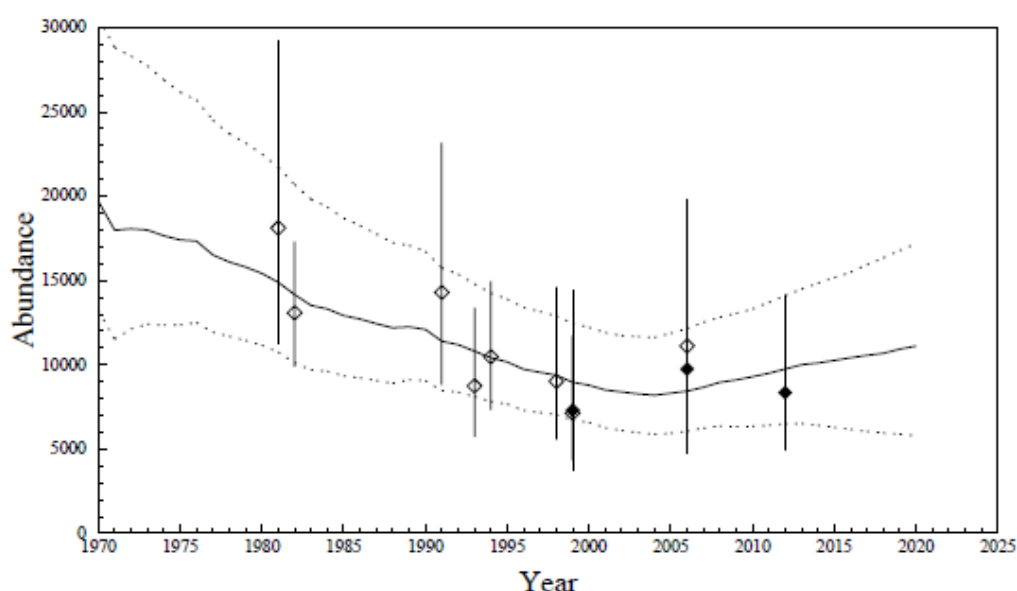
Discussion

The SC **agreed** with the advice and recommendations of the JWG.

Table 2. Beluga in West Greenland. The estimated trade-off between the total annual removal and the probability (P) of an increase in the number of beluga that winters off West Greenland over the period from 2016 to 2020.

P	0.70	0.75	0.80	0.85	0.90	0.95
West Greenland	320	290	260	225	195	145

Fig 2. The estimated dynamics (curves) of the aggregation of belugas that winter off West Greenland, together with the abundance estimates from aerial surveys (absolute estimates solid diamonds; relative estimates open diamonds). The bars and dotted curves show the 90% confidence interval.



8.4.3. Disturbance Symposium

The preliminary findings from the Disturbance Symposium were discussed under agenda item 6.5. The finalized report will be available for discussion at the next SC meeting in 2016.

8.4.4. Update

Studies of beluga whales in Svalbard continue, and have received new funding for three more years. It involves satellite tracking and collection of skin, blubber and blood samples for a large suite of studies. In 2015, only two animals were caught and instrumented.

8.4.5. Future work

No future work was discussed.

8.4.5.1. *JCNB/NAMMCO JWG meeting- spring 2016*

Greenland will likely not have any new information to present to the JWG until 2017, and it will be important for the Canadians to provide new abundance estimates and catch history information before the next meeting. From the NAMMCO perspective, the SC **recommends** waiting until 2017, but recognizes that scheduling a meeting is up to the discretion of the NAMMCO and JCNB JWG Chairs.

8.4.5.2. *Global review of monodontids*

Prewitt informed the SC that the planning for the NAMMCO organised *Global Review of Monodontids* meeting is continuing. The meeting will be held in conjunction (either immediately before or after) with the Marine Mammals of the Holarctic, which recently announced the location and dates of the meeting: 17-21 October 2016 in Astrakhan, Russia.

The organising committee consists of Arne Bjørge (Chair, Norway), Jill Prewitt (NAMMCO), Robert Suydam (North Slope Borough, Alaska, USA), Roderick Hobbs (USA), Steve Ferguson (Canada), Randy Reeves (Canada), Rikke Hansen (Greenland), and Olga Shpak (Russia).

The SC suggested that the organizers inquire whether the Arctic Council's CAFF WG would be interested in joining NAMMCO as co-sponsors for this meeting.

8.5. Narwhal

8.5.1. Review of active requests (R-3.4.9, 3.4.11)

R-3.4.9 (ongoing): *provide advice on the effects of human disturbance, including noise and shipping activities, on the distribution, behaviour and conservation status of belugas, particularly in West Greenland; narwhal added at NAMMCO 22*

R-3.4.11 (standing): *update the assessment of both narwhal and beluga*

8.5.2. Updates

8.5.2.1. *NAMMCO-JCNB JWG report (see ANNEX 2)*

New information on abundance and catches were presented as well as new methodological developments of the allocation model for catches between Greenland and Canada that has been underway for some years.

Catch statistics

Greenland presented a time series of catch statistics from West Greenland during 1862-2014, which was constructed with catches split into hunting grounds and corrected for under-reporting detected from purchases of mattak (low option), for periods without catch records (medium option) and from rates of killed-but-lost whales (high option). Struck and lost rates have been estimated using factors such as community, season, hunting method, and these estimates are included in the catch history that is used in the assessment model.

Canada presented catch statistics and a summary of the process of management advice in Canada. The catch statistics provided by Canada have not been split by summering stocks or struck and lost rates by communities and the JWG reiterated the **recommendation** for Canada to provide corrected catch statistics to include in the assessments.

Abundance estimates

Abundance estimates were presented from the Canadian High Arctic narwhal survey that was conducted in Canada in August 2013, however, they survey was not presented in full detail and it could therefore not be approved for use in assessments. Details of the final analysis of the survey will be presented at a later JWG meeting.

New abundance estimates for narwhals in Melville Bay (one of the two summering areas in West Greenland) based on aerial surveys were presented and these estimates of 2,983 narwhals ($cv=0.39$; 95% CI 1,452-6,127) and 3,091 ($cv=0.50$; 95% CI 1,228-7,783) in 2012 and 2014 were accepted by the JWG for use in the assessment.

Catch Allocation Model

Studies applying satellite-tracking techniques have during the past 20 yrs revealed information on seasonal movements, site fidelity to summering grounds and migratory corridors of some stocks of narwhals in Baffin Bay and adjacent waters. This is also known as the Baffin Bay narwhal metapopulation. Without information on movements, narwhals that are hunted in different regions cannot be attributed to their summering aggregation. In order to assign catches in different hunting grounds and seasons to the appropriate summering grounds, where abundance estimates usually are developed, a so-called allocation model has been under development for several years. It includes all information that is available on narwhal movements including telemetry data, all abundance estimates, seasonal occurrence and historical catch data.

A total of 8 distinct summering stocks of narwhals have been identified and whales from these stocks are hunted at 11 hunting. Different fractions of the migrating stocks of narwhals are available at 11 hunting grounds, during different seasons giving a total of 24 hunts. The allocation model that is developed to mirror these seasonal patterns of occurrence consists of a matrix with 24 rows and 8 columns. The eight columns are the individual summer aggregations of Smith Sound, Jones Sound, Inglefield Bredning, Melville Bay, Somerset Island, Admiralty Inlet, Eclipse Sound, and East Baffin Island.

Thus for each summer aggregation and hunt there is a cell in the matrix, and the matrix is devised so that when multiplied by a number of removals, the resulting number will determine the total removals from each summer aggregation. The cells in the matrix were determined using the tag data, or when no tag data was available, then expert opinion and the relative abundance of each summer aggregation. The tag data determined the fraction of the summer aggregation that was available to a hunt, which was multiplied by the size of the stock to determine the numbers from each summer aggregation exposed to each hunt. The total number of whales available to a hunt to determine the proportion of the hunt that came from the summer aggregation then divided these. The catch allocation model allocates the catches in different hunting areas and seasons to the different summer aggregations. Further refinement of the model included testing of the sensitivity of the allocation to data uncertainty as well as stochastic variation of the matrix from year to year.

In order to develop assessment based on the catch allocation model a Bayesian population modelling of the eight summer aggregations of narwhals in the region was conducted to estimate the impact of the catches on the population dynamics of the eight narwhal aggregations. The assessment model uses population trajectories and catches histories from 1970 to 2014, abundance estimates and data on reproduction to estimate the catches taken from the different summer aggregations during this period. Assessment of the sustainable catch levels from each of the 8 summering stocks are presented in Fig. 3 and Table 3, however, the take of narwhals from the different summering aggregations cannot be managed by consideration of summering grounds exclusively because many narwhals are caught in other hunting areas at other times of the year (e.g., during migration). Instead, management limits for different hunts and season must be considered together.

The difference between current catch levels (C0) distributed by stock and an example of sustainable catch levels developed from the allocation model (C1) is shown in Table 4. The example of a distribution of the sustainable catch levels estimated from the allocation model to the hunting grounds and seasons is shown in Table 5 where the average catch option (C0) uses the average annual take (including struck and loss) in the different hunts over the five year period from 2009 to 2013. The C1 column in Table 4 is an example of the how the catches can be distributed for the period 2015-2020 according to the allocation model.

Some of the summer aggregations, like those in Smith and Jones Sound, have very low catches that have little effect on the dynamics, while the narwhal aggregation in Melville Bay is clearly influenced by the historical takes. The narwhal aggregation around Somerset Island may have an increasing trend, and those in Inglefield Bredning, Admiralty Inlet, Eclipse Sound and East Baffin Island appears relatively stable. The model estimates that nearly all the aggregations are above the maximum sustainable yield level where slightly decreasing trends usually are of no concern (Fig. 3).

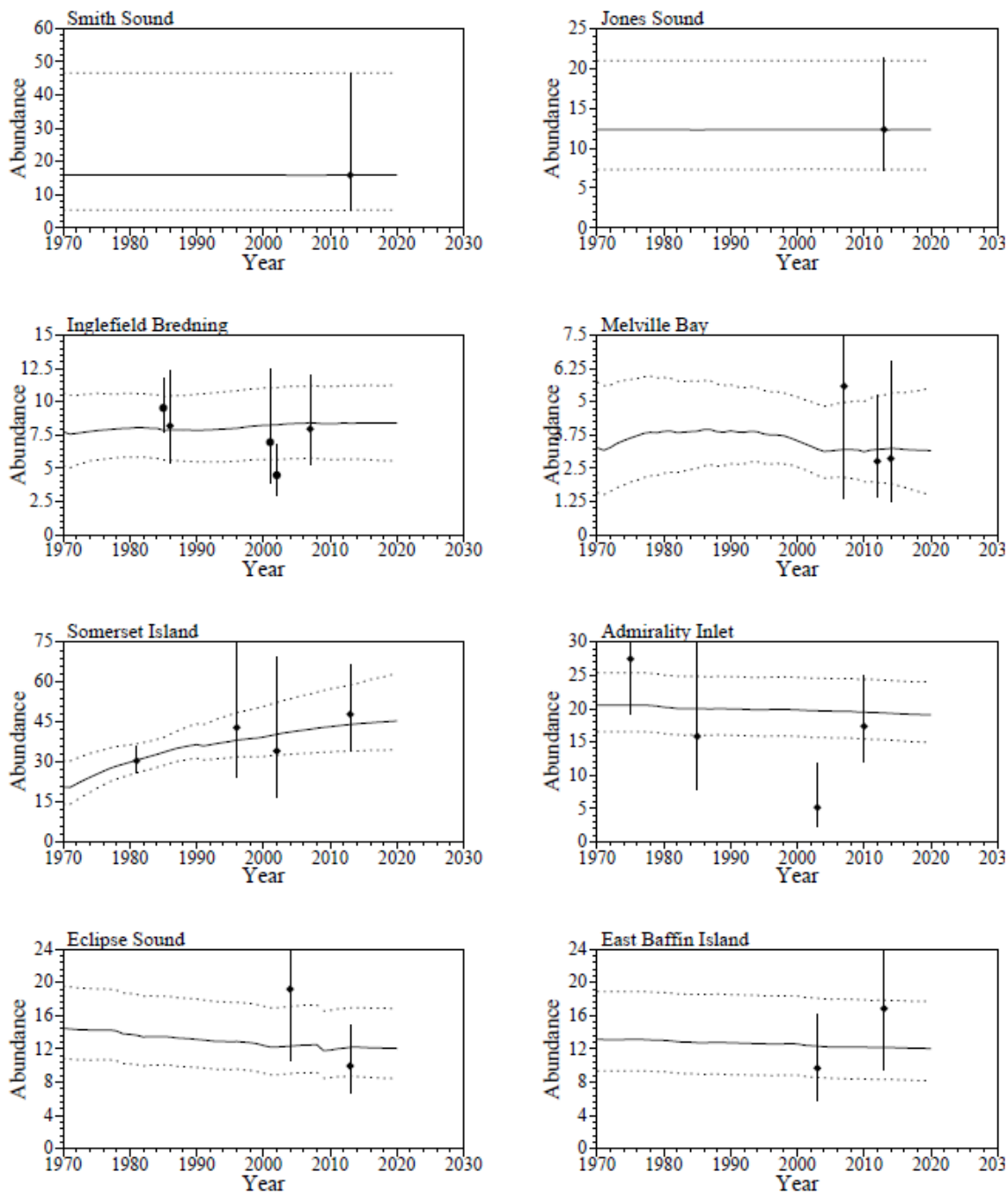


Fig 3. The population trajectories from the assessment model by summering aggregation. The medians (black) and 90% confidence intervals (dotted) of the estimated population dynamics from the eight summer aggregations of narwhals in East Canada and West Greenland, together with abundance estimates from aerial surveys (dots).

Table 3. The total annual removals per stock that meet given probabilities (P) of management objectives. The simulated period is from 2015 to 2020, and this assumes a 50% catch of females.

P	Smith Sound	Jones Sound	Inglefield Bredning	Melville Bay	Somerset Island	Admiralty Inlet	Eclipse Sound	East Baffin Island
0.5	284	231	147	108	914	394	398	192
0.55	259	215	135	102	871	371	377	180
0.6	231	200	123	97	828	347	354	169
0.65	206	186	111	90	780	325	332	158
0.7	185	171	98	82	732	301	310	147
0.75	165	156	83	72	684	273	287	135
0.8	144	141	68	63	635	243	262	123
0.85	123	126	52	53	580	213	234	110
0.9	100	106	33	40	512	177	198	94
0.95	67	78	5	21	403	124	151	72

The NAMMCO SC **agreed** with the recommendations of the JWG and **welcomed** this new methodological development of the complex assessment situation for the narwhal metapopulation that is shared between Canada and Greenland. The advancement of the allocation model is considered a step forward and could potentially be applied in many situations where migratory populations are exploited in several areas under various jurisdictions.

East Greenland

Assessment and updated advice

The assessments of narwhals in the two stocks in East Greenland (Ittoqqortormiit and Tasiilaq/Kangerlussuaq areas) were updated with recent catch information. Population models were fitted to the abundance estimate from 2008 for each stock and an age-distribution sampled from animals caught around Ittoqqortormiit between 2007 and 2010.

The updated assessment estimates a slightly smaller sustainable catch (Table 6) than the previous assessment, reflecting that we are further away in time from the available abundance estimate. The total annual removal was estimated to be no more than 50 for the Ittoqqortormiit area and 16 for the Tasiilaq/Kangerlussuaq.

SC **agreed** with the advice of the JWG. The SC noted that the quota for Tasiilaq was recently increased by 10 narwhals above the previous management advice.

8.5.3. Future work

SC **recommended** that future research includes

- 3) New surveys of narwhals in the two stocks where recommended catch levels has decreased, i.e. East Greenland and Melville Bay
- 4) More satellite tag and dive data from the stocks in West Greenland and Eastern Canada to obtain more information about movement between summer aggregations and information for availability bias for survey correction factors

Table 4. Two potential scenarios of takes of narwhal in the 24 different hunts. C0 represents the current situation with average catches during 2009-2015. C1 represents an example of a projection through 2020.

Hunt	Season	Catch Options	
		C0 (Average)	C1
Etah	Spring	4	5
Qaanaaq	Summer	98	98
Grise Fiord	Spring	7	9
Grise Fiord	Summer	11	15
Grise Fiord	Fall	0	0
Upernavik	Summer	100	70
Ummannaq	Fall	86	154
Disko Bay	Winter	73	97
Central Canadian Arctic	Spring	4	6
Central Canadian Arctic	Summer	74	118
Central Canadian Arctic	Fall	2	3
Arctic Bay	Spring	31	41
Arctic Bay	Summer	141	188
Arctic Bay	Fall	0	0
Pond Inlet	Spring	58	77
Pond Inlet	Summer	55	73
Pond Inlet	Fall	4	5
Baffin Island Central	Spring	12	11
Baffin Island Central	Summer	100	91
Baffin Island Central	Fall	44	40
Baffin Island South	Spring	5	5
Baffin Island South	Summer	9	8
Baffin Island South	Fall	12	11
Baffin Island South	Winter	0	0

Table 5. Examples of future annual removals (C) through 2020 per summer aggregation, with associated probabilities (P) of fulfilling management objectives. The C0 and C1 removals follow from the catch options in Table 4 above, and the 90% confidence intervals of the estimates are given by the sub and super scripts.

	Smith Sound	Jones Sound	Inglefield Bredning	Melville Bay	Somerset Island	Admiralty Inlet	Eclipse Sound	Baffin Island
C0	4 ⁴	18 ¹⁸	98 ⁹⁸	109 ¹⁴¹	219 ²⁶⁵	185 ²²⁶	155 ²⁰⁷	134 ¹⁵²
	4 ⁴	18 ¹⁸	98 ⁹⁸	101 ¹⁰¹	175 ¹⁷⁵	161 ¹⁶¹	104 ¹⁰⁴	120 ¹²⁰
P0	1.00 ^{1.00}	1.00 ^{1.00}	0.7 ^{0.7}	0.49 ^{0.56}	0.99 ^{0.99}	0.89 ^{0.92}	0.95 ^{0.98}	0.76 ^{0.81}
	1.00 ^{1.00}	1.00 ^{1.00}	0.7 ^{0.7}	0.26 ^{0.26}	0.99 ^{0.99}	0.83 ^{0.83}	0.89 ^{0.89}	0.68 ^{0.68}
C1	5 ⁵	24 ²⁴	98 ⁹⁸	83 ¹²⁶	343 ³⁹⁹	243 ²⁹⁶	198 ²⁶²	122 ¹³⁸
	5 ⁵	24 ²⁴	98 ⁹⁸	72 ⁷²	283 ²⁸³	212 ²¹²	134 ¹³⁴	110 ¹¹⁰
P1	1.00 ^{1.00}	1.00 ^{1.00}	0.7 ^{0.7}	0.7 ^{0.75}	0.97 ^{0.98}	0.8 ^{0.85}	0.9 ^{0.96}	0.8 ^{0.85}
	1.00 ^{1.00}	1.00 ^{1.00}	0.7 ^{0.7}	0.36 ^{0.36}	0.95 ^{0.95}	0.71 ^{0.71}	0.8 ^{0.8}	0.74 ^{0.74}

Table 6. Narwhal in East Greenland. The estimated trade-off between the total annual removal and the probability (P) of an increasing stock from 2015 to 2020, for Ittoqqortormiit and Tasiilaq in East Greenland.

P	0.70	0.75	0.80	0.85	0.90	0.95
Ittoqqortormiit	50	40	30	20	10	4
Tasiilaq	16	13	9	4	1	0

8.5.3.1. Planning JCNB/NAMMCO JWG meeting (taken above in 8.5.3.1)

As noted above, the SC recommends scheduling the next meeting sometime in 2017. See 8.4.5.1 for more details.

8.5.3.2. Global review of monodontids

This item was discussed under item 8.4.5.2.

8.5.3.3. Disturbance symposium

This item was discussed under item 8.4.3.

8.6. Sei whale

8.6.1. Review of active requests (R-3.5.3 amended, 1.7.12)

R-1.7.12 (ongoing): *Greenland requests the SC to give information on sustainable yield based on new abundance estimates expected from NASS2015 for all large baleen whales in West Greenland waters*

R-3.5.3 amended (ongoing): *assess the status of sei whales in West Greenland waters and the Central North Atlantic and provide minimum estimates of sustainable yield*

8.6.2. Update

Iceland reported that there were not very many sightings during NASS2015 but that this was not unexpected as the timing and coverage of the survey was not appropriate for estimation of sei whale abundance.

Iceland informed the SC that they have been requesting a RMP *Implementation Review* in the SC of the IWC, however it was decided at this year's IWC SC meeting to postpone this work.

8.7. Bottlenose whale

8.7.1. Update

The Faroese NPR reported that 5 animals stranded in 2014. The Museum received tissue samples from these animals for analysis of diet, reproduction, etc. and these will be archived.

8.7.2. Future work

No future work was reported.

8.7.3. Abundance estimate

The Faroese data from T-NASS 2007 has been integrated into a model-based assessment of deep diving species being done in the UK. Mikkelsen informed the SC that the manuscript is planned to be submitted within a few months.

8.8. Killer whale

8.8.1. Review of active requests (R-3.7.2)

R-3.7.2 (ongoing): *review the knowledge on the abundance, stock structure, migration and feeding ecology of killer whales in the North Atlantic, and to provide advice on research needs to improve this knowledge. Priority should be given to killer whales in the West Greenland – Eastern Canada area.*

8.8.2. Update

The SC noted that there is still not enough information to answer **R-3.7.2**.

At SC20, the SC noted higher levels of annual catches (19 on average per year from 2010 and 2012) in West Greenland. The SC was then informed that the recent catch statistics on killer whales in West Greenland have not been validated, and at this meeting the SC noted that these catch statistics still have not been validated. The SC **reiterates the recommendation** that all catch data on killer whales are validated before the next SC meeting, so that it is possible for the SC to monitor the development of the hunt.

Iceland informed the SC that there is an ongoing project in MRI on the behaviour, migration, and feeding ecology of killer whales. This work will be finalized by the end of this year. The SC awaits presentation of these results at the next meeting.

8.9. Pilot whale

8.9.1. Review of active requests (R-3.8.3, 3.8.4, 3.8.5, 3.8.6, 1.7.11)

R-1.7.11 (ongoing): *develop estimates of abundance and trends as soon as possible*

R-3.8.3 (ongoing): *to develop a proposal for the details of a cost-effective scientific monitoring programme for pilot whales in the Faroes*

R-3.8.4 (ongoing): *methodology and the coverage of T-NASS take into account the need for reliable estimates for pilot whales. In addition, priority should be given to the analysis of data on pilot whales after the completion of T-NASS*

R-3.8.5 (ongoing): *assess the status of long-finned pilot whales in West Greenland waters and provide minimum estimates of sustainable yield*

R-3.8.6 (ongoing): *complete a full assessment of pilot whales in the North Atlantic and provide advice on the sustainability of catches...with particular emphasis on the Faroese area and East and West Greenland. In the short term...provide a general indication of the level of abundance of pilot whales required to sustain an annual catch equivalent to the annual average of the Faroese catch in the years since 1997*

Discussion

Regarding **R-1.7.11**, the SC awaits results of NASS2015 and expects that these will allow for the development of an abundance estimate, and will be incorporated into the trend analysis.

Regarding **R-3.8.3**, taking into account the recommendations made by the 2008 Pilot Whale WG (Qeqertarsuaq, Greenland) that were organized in response to this request, the Faroes has developed a scientific monitoring programme to update biological parameters. As reported in the NPR, a number of samples have been collected including samples for ageing, reproductive information, and stomach samples for diet. The plan is to continue to collect samples from every drive and deliver results to the next assessment meeting. Based on this information, the SC considers **R-3.8.3 completed** and awaits further guidance from Council.

R-3.8.4 refers to T-NASS 2007, and the SC considers this request now **completed**.

Regarding **R-3.8.5**, the SC considers this request replaced by **R-3.8.6**. The remaining unanswered portions of **R-3.8.6** awaits new data from NASS2015. The West Greenland part was dealt with during SC/19 and the SC refers Council to that report.

8.9.2. Update

The Faroes have been attempting satellite tagging to obtain information on distribution of whales susceptible to catches. Mikkelsen informed that they were not able to tag during the sightings survey activities because of poor weather and difficulties in approaching whale groups. However, they were able to tag 5 whales from one group on 24 August after the survey was completed. One of the 5 tags is collecting dive data. The SC noted that the preliminary results from these animals suggest that pilot whales move widely around in the North Atlantic (Fig. 4).

The SC commended the Faroes for the work on the sampling programme.

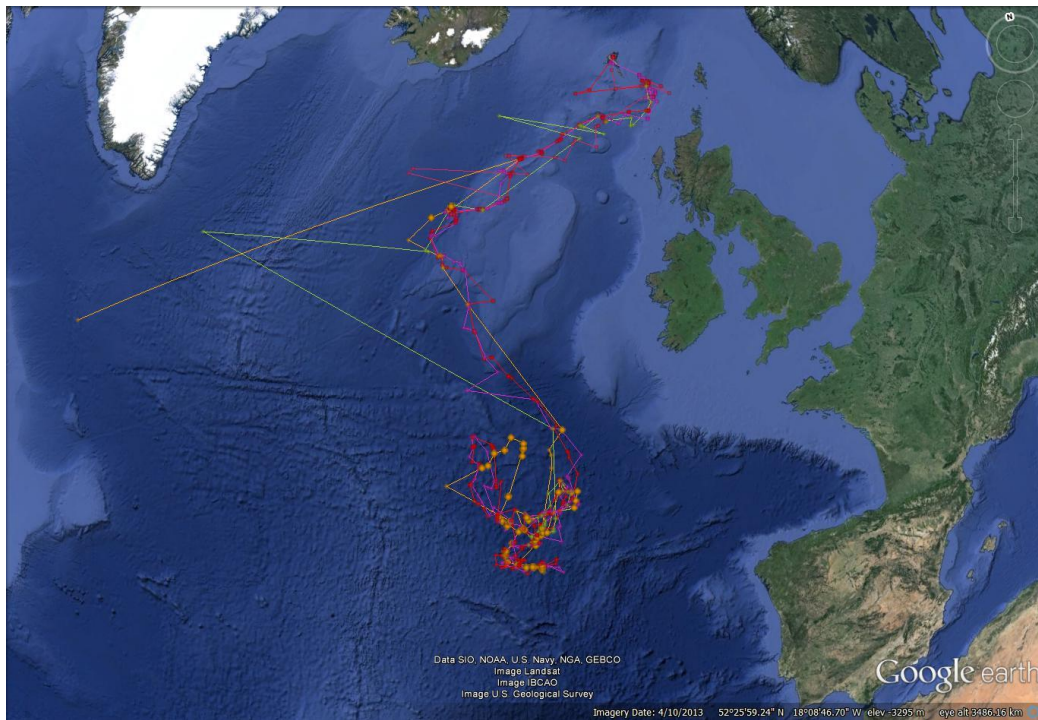


Fig. 4. Movement (unfiltered ARGOS positions) of a group of pilot whales that was tagged in the Faroe Islands 24 August 2015.

8.9.3. Future work

The goal is to have an approved pilot whale abundance estimate in 2016.

In preparation for a new assessment, the Faroes are re-establishing the competence for age and reproduction analysis.

8.10. Dolphins

8.10.1. Review of active requests (R-3.9.6)

R-3.9.6 (ongoing): *assessments of dolphin species*

8.10.2. Update

Some sampling has been occurring in the Faroes previously, however no new samples have been collected recently because there have been very few catches in recent years. The results from the previous sample collections have yet to be published.

Zabavnikov informed the SC that a wider distribution and higher numbers of white-beaked dolphins in comparison previous years had been recorded during the annual Russian-Norwegian ecosystem survey in the Barents Sea in August-September 2014 in the Russian (PINRO) research area (east of 33°E). All recorded animals were observed close to capelin and juvenile cod aggregations.

Lydersen noted the recent observations of polar bears feeding on ice-entrapped white beaked dolphins in Svalbard.

8.10.3. Future work

There are no plans to collect more samples.

8.11. Harbour porpoise

8.11.1. Review of active requests (R-3.10.1)

R-3.10.1 (ongoing): *comprehensive assessment of the species throughout its range*

8.11.2. Update

Tagging of harbour porpoises continues in Greenland, and some of the 2014 tags are still operating. Tissue samples are being collected for various analyses for comparison with previous sampling programs.

8.11.2.1. Status of recommendations from 2013 HPWG

As discussed under item 6.1.1, Norway informed the SC that they are seeking funding and planning studies in response to the recommendations from the 2013 HPWG.

8.11.2.2. Updates on catch/by-catch reporting and numbers

This was discussed under agenda item 6.1

8.11.3. Future work

See above under 8.11.2.1.

8.12. Sperm whale

8.12.1. Update

Sperm whales feeding aggregations occur in the Bleik Canyon, close to shore in North Norway. Haug reported of a study using a whale safari company as a platform from which to conduct a photo-identification study of male sperm whales in the area (Rødland & Bjørge 2015). Data was collected over 22 seasons (1987–2010) of whale-watching tours. The study confirm the presence of both transient and resident male sperm whales in the Bleik Canyon. The results suggest that the sperm whale group(s) found there are a loose feeding aggregation and not a closed population. Total residence time varied between one day and 14 years, although most individuals were only seen in one or two years. The number of sighted whales fluctuated between years, from eight to 77 individuals. No trend in the number of sighted whales was found. The estimated size of the feeding aggregation in the Bleik Canyon also fluctuated between years, from 11 to 116 individuals, with no trend evident.

8.12.2. Future work

No future work was discussed.

8.13. Bowhead whale

8.13.1 Review of active requests (R-1.7.12)

R-1.7.12 (ongoing): *Greenland requests the SC to give information on sustainable yield based on new abundance estimates expected from NASS2015 for all large baleen whales in West Greenland waters*

8.13.2. Update

A strip-width survey estimated 100 (95% CI: 32-329) bowhead whales in the North East Water Polynya off Northeast Greenland in 2009 (Boertmann et al. 2015). This estimate is considerably higher than observations in the past.

A survey was conducted using a ship and helicopter in Svalbard on the ice-edge for polar bears and ice-associated whales including bowhead whales. The helicopter provided 27 of the 28 bowhead whale sightings.

A tourist vessel also reported a sighting of about 100 whales in the Jan Mayen area and photos confirmed that at least some of the whales were bowheads. A paper from these observations are expected next year.

8.13.3. Future work

No future work was discussed.

8.14. Blue Whale

8.14.1 Update

Iceland reported that they had tagged 2 blue whales during 2014.

An increasing number of blue whales are reported in the waters around Svalbard including in inner parts of the fiord systems especially on the west coast. As reported for fin whales, the Norwegian Polar Institute has started instrumenting animals with satellite tracking devices and collect biopsies for studies of genetics diet and ecotoxicology. In 2015, 3 whales were tagged. Blue whales were also detected on the passive acoustic listening devices that have been deployed at various sites around Svalbard and thus collecting data on the phenology of arrival and departures to the area.

8.14.2. Future work

Iceland reported that they did not have any immediate plans for more tagging.

9. SURVEY PLANNING (R-1.7.11, 1.7.12)

***R-1.7.11 (ongoing):** develop estimates of abundance and trends as soon as possible*

***R-1.7.12 (ongoing):** Greenland requests the SC to give information on sustainable yield based on new abundance estimates expected from NASS2015 for all large baleen whales in West Greenland waters*

Survey Planning WG

The SC WG on Survey Planning met in Reykjavík on 14-15 April 2015 (ANNEX 3) under the Chairmanship of Desportes and preceded by a day of survey equipment training. The aim of the meeting was to review the plan of the Icelandic aerial surveys and to facilitate the completion of the planning for the Icelandic-Faroese shipboard surveys. At this late stage, with two vessels departing less than two months later, survey protocols and data collection systems (Faroese and Iceland) were not decided upon yet, and one vessel and some observers (Faroese) still needed to be chartered/hired. The meeting was therefore very practically oriented in order to complete the planning of the survey. At the time of the meeting, it was unknown whether the NAMMCO proposal to the Norwegian Ministry of Foreign Affairs for the Extension surveys (which include the survey of the Jan Mayen area) would be funded.

Resources per area were reviewed. Survey modes and procedures, sighting protocols, stratification, effort allocation and transect design were agreed upon for both the aerial and shipboard surveys. Survey guidelines for observer had not been finalised yet and it was uncertain at that point which data recording equipment and software would be used, both for the aerial and shipboard surveys. NAMMCO funds were used to develop a prototype of a new device to electronically measure and log angles and possible improvement to the device were discussed and agreed upon.

9.1. NASS Debrief

Heide-Jørgensen reported on the post-NASS meeting of the Steering Committee (ANNEX 4). Three surveys constituted extensions of the national surveys were conducted in the four NAMMCO countries in 2015. The three surveys were funded by NAMMCO and were after an application prepared by a Steering Committee established by NAMMCO's FAC.

The three extension surveys included an intensive survey with the purpose of estimating the abundance of pilot whales around the Faroe Islands, an aerial survey of the coastal waters in East Greenland and a ship-based survey around Jan Mayen following methods developed for the Norwegian minke whale surveys.

All the surveys were successfully completed and resulted in valuable data useful for abundance estimation of the target species.

In addition to these surveys, national surveys covered the West Greenland shelf, areas around Iceland and the Norwegian Sea, providing a satisfactory coverage of these waters. Details of the survey effort and number of sightings are provided in the report from the Steering Committee (ANNEX 4).

The recommendations from the Steering Committee include a plan for the analysis and presentation of the results. It is also recommended that the Steering Committee has now completed its task and that further development of the results from the survey should be transferred to NAMMCO SC and its Abundance Estimation Working Group.

Iceland

A PhD student from St Andrews University is planning to perform a spatial analysis of distribution from NASS2015 and previous surveys. Other countries with old NASS data are welcomed to collaborate.

SC **noted** that the Icelandic aerial survey for minke whales was hampered by poor weather conditions and will likely not produce an abundance estimates.

SC **noted** the recommendations of the NASS Steering Committee but recognizes that this group reports to the FAC.

9.2. Plans for analysis/presentation of abundance estimates (WG)

The Steering Committee recommends that a small AEWG with only NAMMCO national participants meet in May.

9.3. Plans for future surveys

9.3.1. Timing

The Icelandic aerial survey in 2015 was hampered by poor weather and the preliminary indications are that an abundance estimate will not be possible from this survey. Iceland is currently seeking funding for a new aerial survey planned for 2016.

The SC noted that Canada, USA and SCANS-III will likely survey in 2016.

9.3.2. Coordination

The SC noted that it is too early to make a decision on coordination of the next NASS.

9.3.3. Ideas for improving planning for next NASS

The SC noted that it may be of interest for NAMMCO scientists to have observers on the SCANS-III survey to benefit from their experience and expertise.

9.4. Issues regarding trends/abundance/distribution of marine mammals in the North Atlantic

It is too early to discuss this item, but after the results of the NASS2015 are available, the SC will discuss this again. The results of the project with the PhD student in St Andrews University discussed above may be of interest for this issue.

9.5. Publications from TNASS-07

The plan is for the TNASS-07 pilot whale data will be combined with both past results and the NASS2015 data in a trend analysis.

The SC noted that it is unfortunate that not all of the TNASS-07 data has been published, but at this point there may be results forthcoming from the NASS2015 survey and therefore it makes sense to wait for the analyses from the recent survey and publish them together.

9.6. Future work

As discussed above, the SC recommends that the AEWG will meet in May. There will be a very short pre-meeting (via teleconference) to determine whether the analyses are on track for a May meeting.

10. NAMMCO SCIENTIFIC PUBLICATIONS

10.1. Monodontid age estimation

The Monodontid volume is still ongoing and will hopefully be finalized in early 2016.

10.2. Next volume

The SC discussed plans for future volumes in the series. One idea is a survey volume which contains any previously unpublished NASS papers, and the new results from NASS2015.

Another possible future volume would be papers from the planned Global Review of Monodontids. Of particular interest are papers from Russian scientists that will present their projects at this meeting. This would be especially helpful because these scientists usually do not publish in English, and therefore their information is usually not accessible.

The SC recommended continuing with themed volumes due to the increase in the workload that is likely to occur if the journal was to accept individual papers.

11. DATABASES ON ABUNDANCE AND CATCHES

11.1. Abundance

The Secretariat is working on compiling a table of the abundance estimates that are used in the assessments. The draft table was provided for the SC's input on the data that is being compiled.

11.2. Catches

The Secretariat is also working on compiling the catch data from the NPRs. This table is mainly for information to managers and the public and is not necessarily the catch histories that are used in the assessments.

12. WORK PROCEDURES IN THE SC

12.1. Involvement of the Vice-Chair

The Vice-Chair has been involved in the presentation of the SC report at the last few Council meetings, and this is the first year that the Vice-Chair has been involved in the preparation and running of the SC meeting. The SC noted that this is a good way to continue.

12.2. Guidelines for chairing the SC

The SC discussed two main issues with respect to the Guidelines:

- 1) Election of chair and vice chair. The normal practice has been that it follows the rotation of member countries, however this set of guidelines notes that it is not necessary to follow the rotation of countries.
- 2) Involvement of the Vice chair. The SC noted that the Vice Chair can and should be involved before the meeting, during the SC meeting and also during the Council meeting.

The SC **agreed** that the Secretariat shall prepare a draft of an Executive Summary of the SC Report for a review by the Chair (and Vice Chair). The Chair has the responsibility for the final version of the Executive Summary.

12.3. New meeting procedures

The SC discussed ideas for future meetings to make them as efficient and effective as possible, and to strengthen the SC overall. Some suggestions were to:

- 1) Strengthening scientific collaborations between the scientists in the SC. Among other options for joint projects of interest to all NAMMCO countries, one example is to resurrect the idea of developing satellite-tagging expertise within the SC. This could be done by requesting funds from NAMMCO. Another idea is where SC members could form stronger collaborations is a genetics study.
- 2) Add a new agenda item on "Collaborative work within the SC". The SC agreed that this item would come at the beginning of the meeting so that it can be discussed throughout the meeting.
- 3) Hold the SC meeting every other year, with the alternative year being a tele/video conference. This is in response to the financial concerns related to sending the full complement of SC members to the meetings. This suggestion will be discussed further at the next meeting.
- 4) Encourage SC could members bring presentations (e.g., powerpoint, videos) highlighting research projects.

These and any new suggestions will be discussed further at the next SC meeting.

12.4. Other suggestions

There was a suggestion that the incoming Chair should present their vision for the SC at next year's meeting.

Participants were reminded that the Rules of Procedure details a 10 day deadline for meeting documents to be submitted to the Secretariat, and that everyone should strive to follow these deadlines in order to give everyone sufficient time to read and prepare for the meeting.

12.5. Use of NAMMCO documents

It was noted that use of NAMMCO documents at external meetings should credit NAMMCO.

13. FUTURE WORK PLANS

13.1. Scientific Committee

13.1.1. 2016 Meeting (Greenland)

The SC suggested that it would be a considerable cost and time saving to have the next SC meeting in Copenhagen rather than Greenland. If the meeting is held in Copenhagen, the SC **urged** all countries to send all of their SC members to the next meeting to take advantage of the cost saving.

The timing of the meeting will be during the first or second week of November 2016.

13.2. Working groups

13.2.1. Coastal Seals WG

The CSWG (Chair: Kjell Tormod Nilssen) will meet late February 2016. The likely location is either Copenhagen/Reykjavik/Oslo, to be decided by the Chair in consultation with the Secretariat. The decision will be based on the final participant list. Invited participants (not including SC members) will include 1 person each from the UK, USA, Canada, Sweden and Denmark, and 2-3 Norwegians.

The WG will mainly address **R-2.4.2** and **R-2.5.2**.

The Terms of Reference for the meeting will be for the WG to:

- 1) assess the status of all populations, particularly using new abundance estimate data that are available from Iceland and Norway.
- 2) address by-catch issues in Norway, Iceland, and the Faroe Islands
- 3) re-evaluate the Norwegian management plans (which have been already implemented) for grey and harbour seals.

The SC **recommended** that all of the available grey seal data from the Faroes is presented to the CSWG for review. The SC **recommends** that the CSWG develops specific plans for monitoring grey seals in the Faroes, e.g., obtaining a relative series of abundance (if a full abundance estimate is not possible at this time).

13.2.2. JCNB/NAMMCO Joint WG

Greenland will likely not have any new information to present to the JWG until 2017, and it will be important for the Canadians to provide new abundance estimates and catch history information before the next meeting. From the NAMMCO perspective, the SC **recommends** waiting until 2017, but recognizes that scheduling a meeting is up to the discretion of the NAMMCO and JCNB JWG Chairs.

The Secretariat (Scientific Secretary) will liaise with the JCNB and NAMMCO co-chairs about whether to postpone until 2017.

The next meeting (2016 or 2017) will be hosted by Greenland.

13.2.3. ICES/NAFO/NAMMCO WGHARP

The WGHARP will meet again in August 2016 at the ICES HQ in Copenhagen, Denmark, to review the status and assess the catch potential of harp and hooded seals in the North Atlantic.

Norway has forwarded a request to ICES, which will form the basis for the next WGHARP meeting. The text of the request is below.

“We understand that new information is now available on both the harp and hooded seal stocks. Therefore we would request an assessment of status and harvest potential of the harp seal stocks in the Greenland Sea and the White Sea/Barents Sea, and of the hooded seal stock in the Greenland Sea.

Report of the Scientific Committee

ICES should also assess the impact on the harp seal stocks in the Greenland Sea and the White Sea/Barents Sea of an annual harvest of:

1. current harvest levels,
2. sustainable catches (defined as the fixed annual catches that stabilizes the future 1 + population),
3. catches that would reduce the population over a 15-years period in such a manner that it would remain above a level of 70% of the maximum population size, determined from population modeling, with 80% probability.”

The NAMMCO SC will request 2 experts to be invited.

13.2.4. NAMMCO BYCWG

The SC **recommended** convening a one-day meeting before the CSWG for planning a future meeting and work of the NAMMCO BYCWG. The participants at this meeting should include Mikkelsen and Gunnlaugsson from the SC, Arne Bjørge (Norway) and Desportes from the Secretariat.

The full WG should also incorporate members from outside the marine mammals sphere and the SC (e.g. fishery experts) and outside NAMMCO.

The TOR developed at SC21 for the WG are:

1. Identify all fisheries with potential by-catch of marine mammals
2. Review and evaluate current by-catch estimates for marine mammals in NAMMCO countries.
3. If necessary, provide advice on improved data collection and estimation methods to obtain best estimates of total by-catch over time.

13.2.5. Abundance Estimates WG

A small AEWG will be scheduled for May 2016, with only NAMMCO participants. The location will be Copenhagen or Bergen.

A second meeting may be scheduled in October 2016, depending on progress with the analyses, and could be held back to back with a potential LWA WG meeting in October 2016

13.2.6. Large Whale Assessment WG

A Large Whale Assessment WG may be scheduled before the next SC meeting, after the abundance estimates from NASS2015 are available. The SC recommended inviting Doug Butterworth, but also additional experts to establish additional expertise within the WG, possibly someone from the Butterworth lab. Additional participants (outside of the SC) may include Bjarki Elvarsson and Hiroko Svolvang.

14. BUDGET

14.1. Spending in 2015

Once the 2015 budget is finalised, this will be circulated to the SC for information.

14.2. Budget for 2016/2017

The SC discussed the 2016 budget in relation to the number of invited experts to the WGs.

15. ANY OTHER BUSINESS

15.1. Election of officers

Tore Haug (Norway) was elected as Chair and Bjarni Mikkelsen (Faroes) was elected as Vice Chair of the SC. The SC **welcomed** the incoming officers and look forward to their terms in office.

15.2. New GS vision for NAMMCO

Desportes, as recently appointed General Secretary of NAMMCO, presented her view and visions concerning the future of NAMMCO and specifically the Scientific Committee, as the body generating the management

advice and therefore one key feature in the organisation. NAMMCO has established itself as an effective regional management body that ensures effective conservation and sustainable utilisation of marine resources, with several management success-stories. It has effectively improved hunting methods, with increased animal welfare and hunters' security. Desportes saw the organisation, and the SC, as having reached a cruising speed and a point where one can choose to continue business as usual or secure development and improvement. Focus areas and goals for different terms period, combined to enhanced transparency and increased visibility were key words. Several good stories emanating from the SC in particular deserved awareness that is much more public. She underlined the importance for the SC to be the watchdog, rendering the Council aware of any arising conservation issue. She provided ideas for enhancing and widening the competence of the SC and the visibility and transparency of its work. She mentioned the use of external expert/observer as a key factor in this process.

The SC welcomed the positive nature of this presentation. A number of ideas for strengthening the operation of the SC, and the SC meetings, were discussed after this presentation, and are discussed in items 12.3 and 12.4.

16. MEETING CLOSURE

16.1. Acceptance of report

The report was accepted by correspondence on 26 November 2015.

16.2. Closing remarks

The Chair thanked the participants for their contributions. The SC thanked the Chair Gunnlaugsson for his efforts over the last three years, and thanked Bjarni Mikkelsen for very nice meeting facilities and a pleasant excursion to the old whaling station.

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Appendix 1 - Agenda

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Report of the Scientific Committee

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Appendix 4 – Cooperation with other organisations - Observer's reports

INTERNATIONAL WHALING COMMISSION (ITEM 5.1 IN THE SC REPORT)

A short Summary of the 2015 IWC SC Report with emphasis on issues relevant for NAMMCO countries

The IWC Scientific Committee held its annual meeting in 2015 in San Diego from 22.05 to 03.06. The full SC report can be found on the IWC website: <https://archive.iwc.int/?r=5429>

General RMP issues

In 2013, the SC recommended that $MSYR1 \pm 1\%$ be adopted as a pragmatic and precautionary lower bound for use in trials, and that $MSYR_{mat}=7\%$ be changed to the roughly equivalent $MSYR1 \pm 4\%$. These changes are now being implemented in all IWC trials and also have consequences for catch limits calculated in the NAMMCO context by RMP. (The catch limits in general will be a little larger.)

The SC reviewed the Norwegian proposal for a revised *CLA* using the procedure agreed earlier in the meeting. The Committee focused on the comparison between the 'IWC Tuning' and the 'Norwegian Tuning'. These variants achieve different performance metrics because they are tuned to different median final depletions. However, the lower 5th percentiles of the lowest and final depletion distributions for the 'Norwegian Tuning' are less than those of the 0.6 tuning of the *CLA*. The Committee therefore concluded that the conservation performance of the 'Norwegian Tuning' was insufficient for the Committee to recommend it. It was also noted that the catch performance of the 'Norwegian Tuning' was superior to that of the 'IWC Tuning', but that this came at the expense of satisfactory conservation performance. The Committee speculated that the poorer conservation performance of the 'Norwegian Tuning' might be due to the parameter chosen to tune it (the slope parameter). Basing tuning on other parameters such as the maximum *MSY* rate parameter (perhaps in addition to the slope parameter) may lead to narrower distributions for final and lowest population size.

From a NAMMCO perspective it should be noted that the difference (loss) in conservation performance is minimal, while the difference (increase) in catches is substantial. In case NAMMCO is in need of a management procedure which will give higher catches than RMP with 0.60 tuning, the Norwegian procedure is definitely an alternative.

RMP – Implementation related matters

North Atlantic fin whale Implementation Review

The Committee was unable to complete the *Implementation Review* in 2014, but progress had been made through work by an intersessional steering group and an intersessional workshop, held at Copenhagen in February 2015. It was hoped to complete the *Implementation Review* this year. However, Allison advised that given workload issues in trying to undertake two major *Implementation Reviews* simultaneously, it had been impossible to complete coding of the *Implementation Simulation Trials*. This precluded completion of the *Implementation Review* at the 2015 meeting. A new intersessional workshop is planned for early 2016.

North Atlantic common minke whale *Implementation Review*

Last year, the Committee had hoped it might be possible to complete the *Implementation Review* at the 2015 Annual Meeting. To that end an intersessional workshop had been held in Copenhagen in February 2015. A work plan was established by the workshop. At the annual meeting the Committee noted that fits of the operating models to the actual data were generally good. However, some of the plots identified concerns with the conditioning. After further consideration it agreed that the inability to fit the abundance estimates for two sub-areas was not of major concern and that the truncated distribution for the operating model 'survey' sex-ratio for one sub-area was expected. However, addressing concerns over trends in abundance of mature females for one sub-stock and trends in abundance of 1+ animals in one sub-area appear to be caused by the 'entry' specifications of the mixing matrices. The Committee recommended that the mixing matrices be changed. In conclusion, despite considerable work, conditioning has not yet been successfully achieved. The Committee noted that the issues identified could only be detected once the full set of 100 replicates had been conducted. It also agreed to organize an Intersessional Workshop early in 2016.

Aboriginal subsistence whaling management procedure (AWMP)

The primary issues at this year's meeting comprised: (1) developing *SLAs* (*Strike Limit Algorithms*) and providing management advice for Greenlandic hunts, with focus on bowhead and fin whales; (2) providing management advice for the Greenland hunts and the humpback whale hunt of St. Vincent and The Grenadines; and (3) additional work related to the AWS (aboriginal subsistence whaling management scheme). Considerable progress on items (1) and (3) was made as a result of an AWMP intersessional Workshop.

In Greenland, a multispecies hunt occurs and the expressed need for Greenland is for 670 tons of edible products from large whales for West Greenland; this involves catches of common minke, fin, humpback and bowhead whales. The flexibility among species is important to the hunters and satisfying subsistence need to the greatest extent possible is an important component of management in the light of the agreed IWC objectives. For a number of reasons, primarily related to stock structure issues, development of *SLAs* for some Greenland aboriginal hunts (especially for common minke whales) is more complex than previous *Implementations* for stocks subject to aboriginal subsistence whaling. The Committee endorsed an interim safe approach to setting catch limits for the Greenland hunts in 2008, noting that this should be considered valid for two blocks i.e. the target will be for agreed and validated *SLAs*, at least by species, for the 2018 Annual Meeting at the latest.

Development of an *SLA* for the common minke whale hunt off Greenland

The complexity of the stock structure situation for common minke whales combined with the level of need (at present the annual strike limit is 164 – the highest allowed under the interim *SLA*) mean that the simple yet conservative approach adopted for fin whales cannot be applied for the common minke whale hunt. Depending on progress with the RMP *Implementation Review* at the present meeting, it may be possible to begin preliminary testing of initial candidate *SLAs* during the proposed forthcoming intersessional workshop. The Committee agrees to allocate highest priority to developing an *SLA* for this hunt in time for its recommendation to the Commission by 2018 at the latest.

Development of an *SLA* for the bowhead whale hunt off West Greenland

Considerable progress on the development of an *SLA* for the bowhead whale hunt had been reported last year. This continued intersessionally and at the February 2015 Intersessional Workshop, the focus was on reviewing the performance statistics and plots for revised candidate *SLAs*. The Workshop received the results from two developing teams for several candidate *SLAs*. Based upon the different properties of these *SLAs* and their performance, the Workshop developed three new 'combined' *SLAs* that performed better than their individual components. One of these slightly outperformed the other with respect to need satisfaction. Based upon these results³, the Workshop recommended that *SLA* to the Committee as the '*WG-Bowhead SLA*'.

At this meeting, new information was received about an increase in the quota for Canada in 2015 to seven that warranted further consideration; the catch off Canada during 2014 was two whales, against a quota of five. The Committee focused its work on determining that the *SLA* recommended at the February workshop is robust to reasonable assumptions made regarding future Canadian catches.

Aboriginal subsistence whaling management advice

Eastern Canada and West Greenland bowhead whales

No bowhead whales were taken in West Greenland in 2014 while two bowhead whales were taken in northeast Canada in 2014. Samples were reported to have been collected from one of the whales taken in Canada and 45 biopsy samples had been collected from West Greenland bowhead whales in 2014. The Committee welcomes this information and recommends continuation of the work. It also strongly encourages collaboration with Canada on genetic work. The Committee recalls that last year, it had agreed that the mark-recapture estimate of 1,274 (CV=0.12) for 2012 provides the best estimate of abundance for the number of bowhead whales visiting West Greenland.

Management advice: Based on the agreed best 2012 estimates of abundance for bowhead whales (1,274 CV=0.12), and using the agreed interim approach, the Committee repeats its advice that an annual strike limit of two whales will not harm the stock.

Common minke whales off West Greenland

Report of the Scientific Committee

Management advice: In 2009, the Committee was able to provide management advice for this stock for the first time (IWC, 2010b). This year, using the agreed interim approach and last year's revised estimate of abundance (16,100 CV=0.43), the Committee advises that an annual strike limit of 164 will not harm the stock.

Common minke whales off East Greenland

Management advice: Catches of minke whales off East Greenland are believed to come from the large Central stock of minke whales. The most recent strike limit of 12 represents a very small proportion of the Central stock (see Annex E, table 3) The Committee advises that the strike limit of 12 will not harm the stock.

Fin whales off West Greenland

Management advice: Based on the agreed 2007 estimate of abundance for fin whales (4,500 95% CI 1,900-10,100), and using the agreed interim approach, the Committee advises that an annual strike limit of 19 whales will not harm the stock.

Humpback whales off West Greenland

Management advice: Based on the Humpback SLA that was agreed by the Commission last year, the Committee agrees that an annual strike limit of 10 whales will not harm the stock.

Management advice was also given for the hunt of humpback whales off St Vincent and the Grenadines, the hunt of the North Pacific Grey whales, and the hunt of the BCB Seas stock of bowhead whales. The advices were all without surprises.

Environmental concerns

The Committee discussed effects of pollution, marine debris, anthropogenic sound and climate change on cetaceans. In March 2014, the IWC held a workshop on the impacts of increased marine activities on cetaceans in the Arctic.

Ecosystem modelling

For the last five years the Committee has discussed apparent declining trends in blubber thickness and body condition in Antarctic minke whales over the 18 years (1987/88-2004/05) of the JARPA special permit programme. This item is relevant to ecosystem modelling because the findings have implications for energetics, reproductive fitness, foraging success, and the prey base itself, all of which are important as input in models. A number of concerns have been raised and addressed on the statistical methods that were used to derive these trends. Following considerable discussion the Committee concluded that there was not sufficient support to modify its conclusion from last year that 'a decline in blubber thickness and in fat weight that was statistically significant at the 5% level had occurred'.

Scientific permits

There was considerable difficult discussions on the proposed new Japanese research programme NEWREP-A. A JARPN II review workshop is planned for February 2016.

ASCOBANS (ITEM 5.2 IN THE SC REPORT)

Observer report from the 22nd ASCOBANS Advisory Committee meeting, The Hague, Netherlands, 29 September – 1 October 2015

Desportes attended the AC 22 meeting, organized as usual in two sessions: a scientific session and an institutional session. A number of reports were presented and discussed that emanated from various working groups appointed under ASCOBANS. Three of these focused on harbour porpoise conservation at a regional level in the remit of three regional Action Plans covering the Baltic, the Western Baltic, Belt Sea and Kattegat, and North Sea. Other working groups deal more generally with Threats to Small Cetaceans (By-catch, Underwater Noise, Negative Effects of Vessels and Other Forms of Disturbance, Pollution and its effects, Marine Debris). The meeting reviewed new information on threats to small cetaceans and considered necessary steps in order to mitigate impacts of human activities on the animals and their habitats. Emerging issues were the impact of Climate Change and the development of Marine Renewable Energy, as well as ways of Managing Cumulative Anthropogenic Impacts on the Marine Environment. AC 22 was the last Advisory Committee Meeting before the 8th Meeting of the Parties (MOP8, Helsinki, Finland, 30 August - 1 September 2016), and the focus was on the decisions to be prepared for consideration and adoption at MOP8. Several topics were

agreed upon that drafting groups will now elaborate on: PCBs, underwater unexploded ordnance, managing cumulative impacts on small cetaceans, best practice regarding necropsy and rescue of small cetaceans, and marine renewables. Work would also be carried out in order to update the Recovery Plan for Baltic Harbour Porpoises (Jastarnia Plan), and to advance the development of a Conservation Plan for Common Dolphins. The terms of reference for such a plan were agreed and a Steering Group was established. Two workshops were planned for 2016, one on *Conserving Europe's cetaceans through synergy-building between the relevant legislative frameworks* (joint ECS/ASCOBANS/ACCOBAMS in conjunction with the 2016 European Cetacean Society Conference), and one carrying forward the Agreement's work on management procedures relating to anthropogenic removal of small cetaceans. The Special Species Session at the 23rd Meeting of the Advisory Committee will feature the white-beaked dolphin, a species of interest to NAMMCO.

The North Sea Group – the steering group for the Conservation Plan for the Harbour Porpoise in the North Sea – held its 5th meeting prior to AC 22 on September 28. Conclusions continued to be that monitoring of marine mammal by-catch in the North Sea remains inadequate. Proper data are still lacking for a reliable impact assessment, because of inadequate and insufficient monitoring of the various net fisheries. Better quality data on by-catch rates and fishing effort for net fisheries were required from EU Member Countries before an assessment could be refined and conclusions drawn as to the overall by-catch of harbour porpoise in the North Sea. Focus was on finalising the position of ASCOBANS on the requirements of EU legislation to address monitoring and mitigation of small cetacean by-catch, to be forwarded to the European Commission.

A workshop on Remote Electronic Monitoring with Regards to By-catch of Small Cetaceans was held on Friday, 2 October.

CMS/ASCOBANS contacted the Faroese Authorities (Executive Secretary of CMS and ASCOBANS, July 27 2015), with a request to provide information on recent hunts, in particular details regarding the species affected by the hunt, how sustainability was assessed, what regulations and management were in place, and how the catches were utilized. The answer from the Faroes (Foreign Service, 29 September 2015) reached the ASCOBANS Secretariat during the AC meeting and was therefore not discussed at the meeting.

Two interesting presentations of interest to NAMMCO were given. “*Reproductive failure in UK harbour porpoises: legacy of pollutant exposure?*”⁴ presented results suggesting that reproductive failure could have occurred in up to 39% or more of mature females sampled and estimated a pregnancy rate of 50% for “healthy” UK females, lower compared to other populations. The results raise concerns about the current and future population-level effects of PCBs on the continuous-system North-east Atlantic harbour porpoise population. Even though previous research⁵ reported that bycaught harbour porpoises in the North Sea were in a poorer health status than their more northern counterparts from Iceland and Norway, the results should be of concern to NAMMCO. Although the use and production of PCBs in Europe was phased out in the 1980s, diffuse inputs into the marine environment continue and environmental levels in marine biota (fish and mussels) are either declining slowly, or there is no general improvement⁶.

The pan-European meta-analysis “*Toxic legacy? Severe PCB pollution in European dolphins*”⁷ of stranded (n=929) or biopsied (n=152) harbour porpoises (HP), striped dolphins (SD), bottlenose dolphins (BND) and killer whales (KW) showed that SDs, BNDs and KWs had mean PCB levels that markedly exceeded all known marine mammal PCB toxicity thresholds. These very high mean blubber PCB concentrations are likely to cause population declines and suppress population recovery. Some small or declining populations of BNDs and KWs in the NE Atlantic were indeed associated with low recruitment, consistent with PCB-induced reproductive toxicity. The analysis did not include samples from NAMMCO parties, although these would represent interesting elements of comparison and killer whale samples could be available in Greenland, Iceland and Norway. The lead author confirmed that he would be happy to get the opportunity to collaborate with

⁴ Murphy S, Barber JL, Learmonth JA, Read FL, Deaville R, Perkins MW, et al. (2015) Reproductive Failure in UK Harbour Porpoises *Phocoena phocoena*: Legacy of Pollutant Exposure? PLoS ONE 10(7): e0131085. doi:10.1371/journal.pone.0131085

⁵ Siebert U, Tolley K, Vikingsson GA, Olafsdottir D, Lehnert K, Weiss R, et al. Pathological findings in harbour porpoises (*Phocoena phocoena*) from Norwegian and Icelandic Waters. Journal of Comparative Pathology. 2006; 134(2–3):134–42. PMID: 16527299

⁶ EEA. European Environment Agency. Hazardous substances in marine organisms (MAR 001). Available: <http://www.eea.europa.eu/data-and-maps/indicators/hazardous-substances-in-marineorganisms/hazardous-substances-in-marine-organisms-3>.

⁷ Jepson, P.D., Deaville, R., et al. in press. Toxic legacy? Severe PCB pollution in European dolphins.

NAMMCO colleagues on PCBs in KWs across the entire NE Atlantic region, as well as the PCB issue in cetacean top predators across all European countries.

Possible future scientific cooperation between ASCOBANS and NAMMCO

The assessment of harbour porpoises is an area where ASCOBANS and NAMMCO may want to cooperate or indeed need to cooperate as, in the present state of knowledge, North Sea harbour porpoises are considered a single stock – therefore a shared stock between one NAMMCO party (Norway) and several ASCOBANS parties (Sweden, Denmark, UK, Germany, Netherlands, Belgium, France). The estimation of life parameters, population health status, impact of anthropogenic disturbances and their mitigation are all areas benefitting of a wider expertise.

Within the framework of ecosystem-based management, it seems relevant for NAMMCO to monitor/support monitoring of the actual impact of OC pollutants on marine top predators, to inform conservation management. The development of a Conservation Plan for Common Dolphins may also be an area where the input of NAMMCO could be of interest to ASCOBANS, especially when the distribution of species seems to have extended further North.

INTERNATIONAL COUNCIL ON THE EXPLORATION OF THE SEAS (ICES) (ITEM 5.3 IN THE SC REPORT)

Report from the 2014 and 2015 Activities in ICES

Tore Haug, Institute of Marine Research, Tromsø, Norway

The ICES Working Group on Marine Mammal Ecology (WGMME)

ICES WGMME met at the Institute of Zoology, Zoological Society of London (ZSL), Regent's Park, London, UK, from 9-12 February 2015.

New information on **distribution** and **abundance** of harbour porpoise available from aerial surveys in the North Sea has been compiled and will be used in project DE-PONS (Disturbance Effects on the Harbour Porpoise Population in the North Sea) to identify areas with high porpoise densities and to predict seasonal distribution and density. New information on abundance and trends available for coastal bottlenose dolphins in Scottish and Welsh waters in the UK, in waters west of Ireland, off the Normano-Breton coast of France, and off the north coast of Spain has been collated as well, together with new information on sperm whales and short-finned pilot whales in the Canary Islands. Updated or new information on distribution and abundance of several cetacean species was available from extensive coastal and offshore surveys off France, mainland Portugal and Madeira. Large-scale cetacean surveys are planned for European Atlantic waters in summer 2016 (SCANS-III). Plans for a Mediterranean cetacean survey continue to be pursued.

New results on **population structure**, available for harbour porpoise and bottlenose dolphin have been compiled. Satellite telemetry and static acoustic monitoring data were used to assign boundaries between populations in the North Sea-Skagerrak, the Belt Sea and the Baltic proper. New results from a genetic analysis of harbour porpoise tissue from Iberia, northern Europe and Turkey indicate a level of differentiation of the Iberian population that may warrant categorisation as a separate subspecies. New results from genetic, stable isotope and diet studies indicate that bottlenose dolphin population structure is hierarchical in the Northeast Atlantic, comprising coastal and pelagic ecotypes. The coastal ecotype comprises a north and south population and there are pelagic ecotypes in the Atlantic and Mediterranean. No new information was available on management frameworks.

A **threat** matrix was completed for the main marine mammal species in each regional seas area. While fishery by-catch is a significant concern, especially for harbour porpoise, common dolphin, coastal bottlenose dolphin and ringed seal, contaminants are also a major concern, especially for harbour porpoise, killer whale and bottlenose dolphin. In the Baltic Sea, contaminants and habitat degradation are a serious concern for all resident marine mammal species. In the Bay of Biscay/Iberian Peninsula and Macaronesia, sonar is a significant threat to beaked whales, and in the former area fin whale and sperm whale are threatened by collisions with shipping. The small population of Mediterranean monk seal in Madeira is threatened by habitat degradation, disturbance and deliberate killing. Text on marine mammals has been provided for the ICES Ecosystem Overviews.

Where their distributions overlap, there is some evidence of **negative ecological interactions** between

harbour seals (*Phoca vitulina*) and grey seals (*Halichoerus grypus*). There is spatial variation in their populations trajectories: in some regions both species are increasing (e.g. Wadden Sea, Baltic Sea and Kattegat, Ireland, France) while in other regions harbour seals are declining while grey seal numbers are on the rise (e.g. North Sea, Orkney, Sable Island). Potential interactions (at-sea distribution, competition for prey, haul-out site use, and predation of harbour seals by grey seals) were reviewed. Recent evidence of direct predation of harbour seals by grey seals in the North Sea was highlighted, as well as evidence of predation of harbour porpoises by grey seals in the same region.

The ICES **seals database** was updated with limited data from few countries. It is anticipated that the database will be fully updated in 2015 to contribute to OSPAR's Intermediate Assessment in 2017.

Marine mammals have been included in whole **ecosystem models** (e.g. Ecopath with Ecosim, EwE) and in minimum realistic models (e.g. GADGET), among others, in studies principally focused on trophic relationships, resource competition between fisheries and marine mammals, and consequences for fish stocks. There is the potential to add fishery by-catch mortality of marine mammals to such models although few examples exist where this has been done. Other types of biological interaction (e.g. parasite transmission) have been less well covered. All models have limitations and some kind of validation exercise is essential to confer credibility on the predictions.

The ICES Working Group on Bycatch of Protected Species (WGBYC)

ICES WGBYC met in Copenhagen at ICES headquarters 2-6 February 2015. Since the commencement of WGBYC in 2009, the WG has been collating, storing and summarizing **annual by-catch and monitoring effort data** reported by European member states affected by EC Regulation 812/2004. This has resulted in the development of WGBYC database that currently stores eight years (2006–2013) of data on cetaceans as reported to the European Commission by member states affected by the regulation. WGBYC continues to cooperate with the ICES Data Centre and make advances toward a more comprehensive database design.

This year WGBYC undertook an historical review of Reg. 812 to the extent practicable. A significant limitation in evaluating the magnitude of by-catch mortality since the implementation of the regulation is not having an accurate estimate or census of total fishing effort from relevant European waters. There is considerable uncertainty in the representativeness of total fishing effort reported by member state to the European Commission. In addition, WGBYC has continually reported on the inconsistent submission and content of annual reports by some member states and the shortcomings of the Reg. 812 to accurately reflect the true magnitude of cetacean by-catch in gears affected by the regulation.

Total observer effort reported by member states in relation to Reg. 812 was highest in the North Atlantic, followed by the Baltic, Mediterranean, and North Sea. This result generally applies to both gillnets and pelagic trawls. Based on Reg. 812 reporting, common and striped dolphins are taken as by-catch in both gillnet and pelagic trawl gear. Harbour porpoise by-catch is only evident in gillnets and bottlenose dolphins have been recorded taken as by-catch in both gillnet and pelagic trawl gears. For gillnets, harbour porpoise by-catch rates were on average lowest in the Baltic, followed by the North Sea/Eastern Arctic with the highest by-catch rates on average in the North Atlantic. Common and striped dolphin by-catch rates in gillnets were also reported for the North Atlantic regional coordination meeting (RCM) but were lower than harbour porpoise by-catch rates from the same area. For pelagic trawls, the North Atlantic common dolphin by-catch rate was higher on average than by-catch rates reported for bottlenose and striped dolphins from the Mediterranean and Black Sea. Potential significant sources of uncertainty in by-catch rates include missing data and different monitoring duties among regions. Mediterranean by-catch rates for gillnets are expected to be underestimated due to the lack of monitoring requirement under Reg. 812. In addition, North Atlantic and Mediterranean by-catch rates for pelagic/midwater trawls are likely underestimated due to missing data from Finland (since 2008), France (2012–2013), Spain (since 2009) and Sweden (since 2013).

WGBYC continues to develop a **by-catch risk assessment** with the aim of identifying regions that may pose the greatest threat to nontarget species in the absence of reliable data that would be needed to quantify the by-catch of protected, endangered and threatened species in a statistically rigorous manner. The WG applied a by-catch risk assessment to harbour porpoise where a range (high/low) in by-catch levels were estimated for regions within greater European Atlantic waters (i.e. Celtic and Irish Seas, North Sea, and Kattegat and Belt Seas). Data for the Celtic and Irish Sea assessment unit suggest that 1.39% of the harbour porpoise population

is being taken if the upper 95% confidence limit by-catch rate is applied. This falls short of the 1.7% limit established by ASCOBANS. The North Sea and Kattegat Seas upper limit mortality estimates fell below 1.00% of their respective abundance estimates. However, many caveats apply to this upper limit, with the effort data reliability and the potential for biases involved. The WG will continue to improve upon and apply the by-catch risk assessment approach to other species/taxa as more data become available.

Several member states continue to design and test various **mitigation methods** to minimize by-catch of protected species. Current mitigation research includes continued development of a porpoise Alarm in German waters, development of fisher brochures of best practices for reducing by-catch in Portuguese waters, continued research on pinger effectiveness in Danish and UK waters, and the development of alternative fishing gears in Swedish waters. WGBYC seeks a continued commitment by its members to support and engage in the development and implementation of mitigation research by seeking funding sources and collaborative re-search proposal ideas.

The ICES Working Group on Harp and Hooded Seals (*ICES WGHARP*)

ICES WGHARP now the ICES/NAFO/NAMMCO Working Group on Harp and Hooded Seals (WGHARP) met during 17-21 November 2014 Quebec City, QC Canada, to consider recent research and to assess the status and harvest potential of harp seal stocks in the White Sea/Barents Sea and in the Northwest Atlantic. The WG received presentations related to catch (mortality) estimates, abundance estimates, and biological parameters of all the stocks in question. Additionally, the WG examined different management options and subsequent scenarios of reductions of the Northwest Atlantic harp seal stock.

The 2015 ICES Annual Science Conference (ASC)

ICES ASC was held in Copenhagen, Denmark, 21-25 September 2015. The conference included no particular theme session devoted entirely to marine mammals. Nevertheless, some sessions were designed with marine mammals included as an integral part – particular relevant sessions were: “Operationalizing ecosystem-based fisheries management”, “Ecosystem monitoring in practice” and “How to hit an uncertain moving target: achieving Good Environmental Status under the Marine Strategy Framework Directive”. More information is available at the ICES web site www.ices.dk.

JCNB (ITEM 5.4 IN THE SC REPORT)

No observer’s report was available, but see discussion under Items 5.4, 8.4, and 8.5.

ARCTIC COUNCIL (ITEM 5.5 IN THE SC REPORT)

Observer report from Arctic Council related meetings

Arctic Council WGs (PAME, CAFF, AMAP, ACAP) Board Meeting

Desportes observed at two Working Group, PAME (September 15) and CAFF (September 16 and 17) and also joined the joint meeting of the four WG, PAME, CAFF, AMAP, ACAP (September 16am).

The information brought up to the PAME WG, although interesting was mostly not directly relevant to the present work of NAMMCO, except for the discussions related to Ecosystem-based Approach and Ecosystem-based Approach. One interesting presentation though was on a new arctic initiative, the Arctic Future Initiative (AFI)⁸, of which NAMMCO may want to follow the development.

Several agenda points of the CAFF WG were more relevant. Among the interesting points were:

- “Provisional Ideas for Studies of Ice-Associated Marine Mammals”, prepared by the US and Norway.
- Discussion on the development towards integrated sets of ecological objectives, which is also going on in EU (MFSD) and OSPAR.
- Discussion on Marine Protected Areas. Both CAFF & PAME⁹ are promoting a network of MPAs throughout the Arctic.
- WWF strategy for the Arctic

⁸ <http://www.iiasa.ac.at/web/home/research/arctic-futures.html>

⁹ https://oaarchive.arctic-council.org/bitstream/handle/11374/417/MPA_final_web.pdf?sequence=1&isAllowed=y

The feedback to the presentation on NAMMCO activities in the Arctic¹⁰ given at the PAME WG was positive. The Alaska ICC-chair, J. Stotts thanked NAMMCO for saying so directly that marine mammals were resources, as other marine resources. The US raised the question about the inclusion of traditional knowledge and local communities in the work of NAMMCO. N. Kutaeva from the Marine Rescue Service of Rosmorrechflot (MRS), Russia, said that she had seen on the web a video on the Faroe Islands where 800 dolphins were killed as sport and asked whether NAMMCO was doing anything about it. The answer was that that take had been mentioned in the talk and was regulated and NAMMCO had conducted an assessment and was planning to update it. The drive fishery was considered sustainable and was well regulated by the Faroese authorities. Kutaeva kept answering that this was different, and was not removals and not whales but dolphins hunted for sport. However later on at the evening event that anything could be found on the internet, also on Russia.

Some directly interesting and relevant contacts were made:

UNEP - Takehiro Nakamura, Chef of the Marine and Coastal Ecosystems Unit, Division of Environmental Policy Implementation. Discussion, a.o., on the Food Security Issue and the fact that marine mammals were usually not considered as resources in the UN documents;

EEA – Nikolaj Bock, Special Advisor on International Affairs, on NAMMCO attitude to marine mammals and relationship with ICES and EU;

OSPAR – Darius Campbell, Executive Secretary. Discussion, a.o., on reinforcing the cooperation between OSPAR and NAMMCO;

CAFF – Tom Barry, CAFF Executive Secretary & **Tom Christensen**, CBMP Co-Chair. On increasing cooperation between CAFF and NAMMCO, and the possible participation of NAMMCO in the next meeting of the Marine Mammal Expert Network in Pasvik, NO, Nov 2-6;

CAFF Secretariat - Nina B. Vaaja, J. Hämäläinen, A. Meldgaard, on functioning and procedures in both secretariat and possible cooperation and exchange.

CAFF's Marine Expert Network (MEN) meeting, Pasvik, Norway, November 3-5, 2015

The Circumpolar Biodiversity Monitoring Program (CBMP - www.cbmp.is) is the cornerstone programme of the conservation of Arctic Flora and Fauna (CAFF - www.caff.is), the biodiversity Working Group of the Arctic Council. It is an international network of scientists, governments, Indigenous organisations and conservation groups working to harmonize and integrate efforts to monitor the Arctic's living resources. Its goal is to facilitate more rapid detection, communication, and response to the significant biodiversity-related trends and pressures affecting the circumpolar world. The CBMP organizes its efforts around the major ecosystems of the Arctic, marine, freshwater, terrestrial and coastal.

The CBMP has been endorsed by the Arctic Council and the UN Convention on Biological Diversity and the official Arctic Biodiversity Observation Network of the Group on Earth Observations Biodiversity Observation Network (GEO BON).

The CBMP – Marine held its annual meeting in Norway November 3rd – 5th at Svanhovd Conference Center in Pasvik, Finnmark. **The focus of the meeting was making progress on the** draft of the State of the Arctic Marine ecosystem Report (SAMBR) developed by the Circumpolar Biodiversity Monitoring Programme (CBMP). The report is scheduled to be completed and delivered to an Arctic Council Ministerial meeting in early 2017. The SAMBR is the first primary product from the implementation of the CBMP's Arctic Marine Biodiversity monitoring plan. It will present baselines and (where possible) trends in Arctic marine biodiversity at different trophic levels and by Arctic Marine Areas. The attendees had presentation on and discussed the state of Arctic sea ice biota, plankton, benthos, fishes, seabirds and marine mammals, and what was driving changes.

The Marine Mammal Expert Group, where NAMMCO was observer, met and made progress on the section of the report related to Marine Mammals. NAMMCO brought attention to the new abundance estimate and updated trends and assessment on different stocks of marine mammals, in particular narwhal, beluga and walrus, referring in particular to the latest reports of the Joint JCNB Working Group.

¹⁰ http://www.pame.is/images/05_Protectec_Area/2015/PAME_2/Presentations/AMSA_4.9_-_NAMMCO_Presentation.pdf

ANNEX 1 - Report of the SC WG on Large Whale Assessment

Copenhagen, Denmark, 5-7 October 2015

1. OPENING REMARKS

Chairman Lars Walløe welcomed the assessment working group (WG) to the Greenland Representation. He noted that Geneviève Desportes was unfortunately not able to attend the meeting, and that Lars Witting would be attending on Tuesday and Wednesday only. The decision was made to start the meeting with fin whales because Lars Witting's input was necessary mainly for the common minke and humpback whale sections.

Previously (2011) the WG agreed on the high value of the process in the IWC of developing the Revised Management Procedure (RMP) and Aboriginal Whaling Management Procedure (AWMP), and especially of the concept of feedback control mechanisms based on regular abundance estimates, catch history and a population model. It also agreed that these principles are valuable and worth carrying over into any NAMMCO management process.

As far as the WG was aware, there had not been any additional work done on the common minke whale *Implementation Review* since the 2015 IWC SC meeting in San Diego.

For the fin whale work in the IWC SC, there is still some work to do on conditioning, etc., but the *Implementation Review* analyses are nearly complete.

2. ADOPTION OF THE AGENDA

The revised agenda (Appendix 1) was adopted.

3. APPOINTMENT OF RAPPORTEUR

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

4. REVIEW OF AVAILABLE DOCUMENTS AND REPORTS

The WG reviewed the available documents.

5. NORTH ATLANTIC COMMON MINKE WHALE

Background

The NAMMCO SC has been requested (R-3.3.4) to conduct a full assessment, including long-term sustainability of catches, of common minke whales in the Central North Atlantic. At NAMMCO/23, Council adopted amendments to request R-3.3.4 to be changed to the following text: "The SC is requested to complete assessments of common minke whales in the North Atlantic and include estimation of sustainable catch levels in the Central North Atlantic. While long-term advice based on the outcome of the RMP *Implementation Reviews* (with 0.60 tuning levels) is desirable, a shorter-term, interim advice may be necessary, depending on the progress within the IWC. This work should be completed before the annual meeting of the SC in 2015."

Assessments

Past assessments for all regions of the North Atlantic have been completed by the IWC SC starting in 1992.

Assessments in NAMMCO using Hitter-Fitter models of the Central North Atlantic common minke whale population have been presented in previous reports (NAMMCO 2003, 2009). These assessments, together with projections under the future catch levels specified by the Council, were conducted for both the CIC *sub-area* and the complete Central *Medium Area*, and for $MSYR_{1+}$ values of 1%, 2% and 4%.

Regarding stock structure, recent examination of mainly genetic data has failed to provide clear evidence of stock structure amongst common minke whales in the North Atlantic, except for small differences on an ocean-wide scale (IWC 2014). While this may suggest a single ocean-wide stock with incomplete mixing, in a

management context in the IWC SC it has been decided operate with three stocks at a “Medium Area” level, i.e., a Western (W), Central (C) and Eastern (E) stock (Fig. 1). The WG endorses the single-stock hypothesis, and the use of the W, C and E Management Areas.

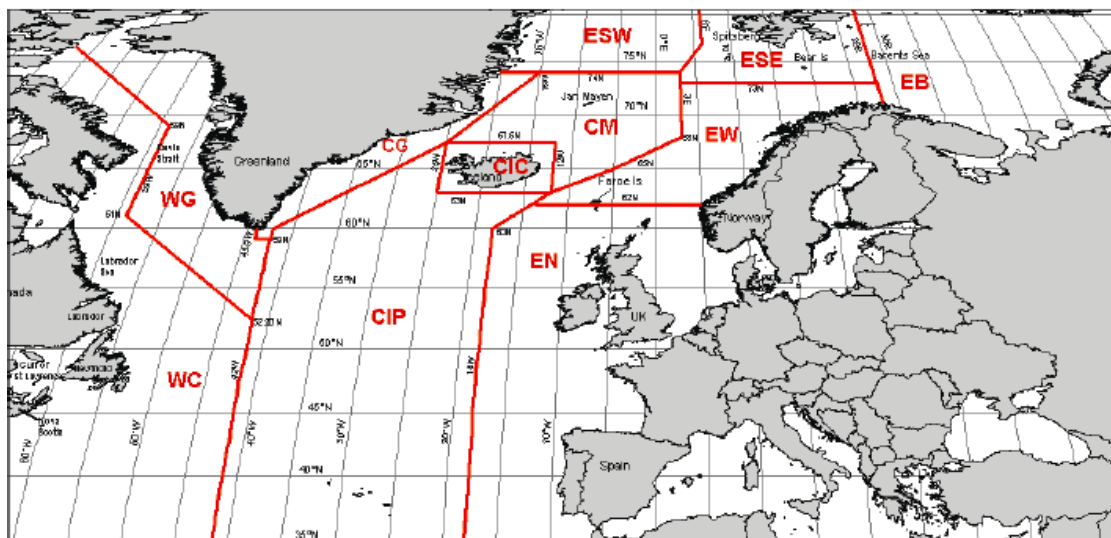


Fig. 1. Map of the North Atlantic showing the sub-areas defined for the North Atlantic common minke whales.

The most recent assessments available on this basis are those that constitute part of the conditioning of the trials in the current ongoing, though now virtually complete, IWC *Implementation Review* for North Atlantic common minke whales. Although a few small adjustments still need to be made, the WG considered that the existing results provide an up-to-date and reasonably robust indication of the current status of common minke whales in the North Atlantic.

Figure 2 reproduces existing results from some baseline trials (IWC 2015) from this conditioning for a scenario of three stocks (W, C and E) with some overlap on their northern feeding grounds, and with the E stock split into two sub-stocks. The mature female trajectories shown indicate that these populations have either:

- i) never been substantially reduced below their pre-exploitation levels, or
- ii) been earlier reduced by no more than about 50%, but recently have been increasing.

Hence these assessments do not indicate any reason for concern about the status of common minke whales in the North Atlantic.

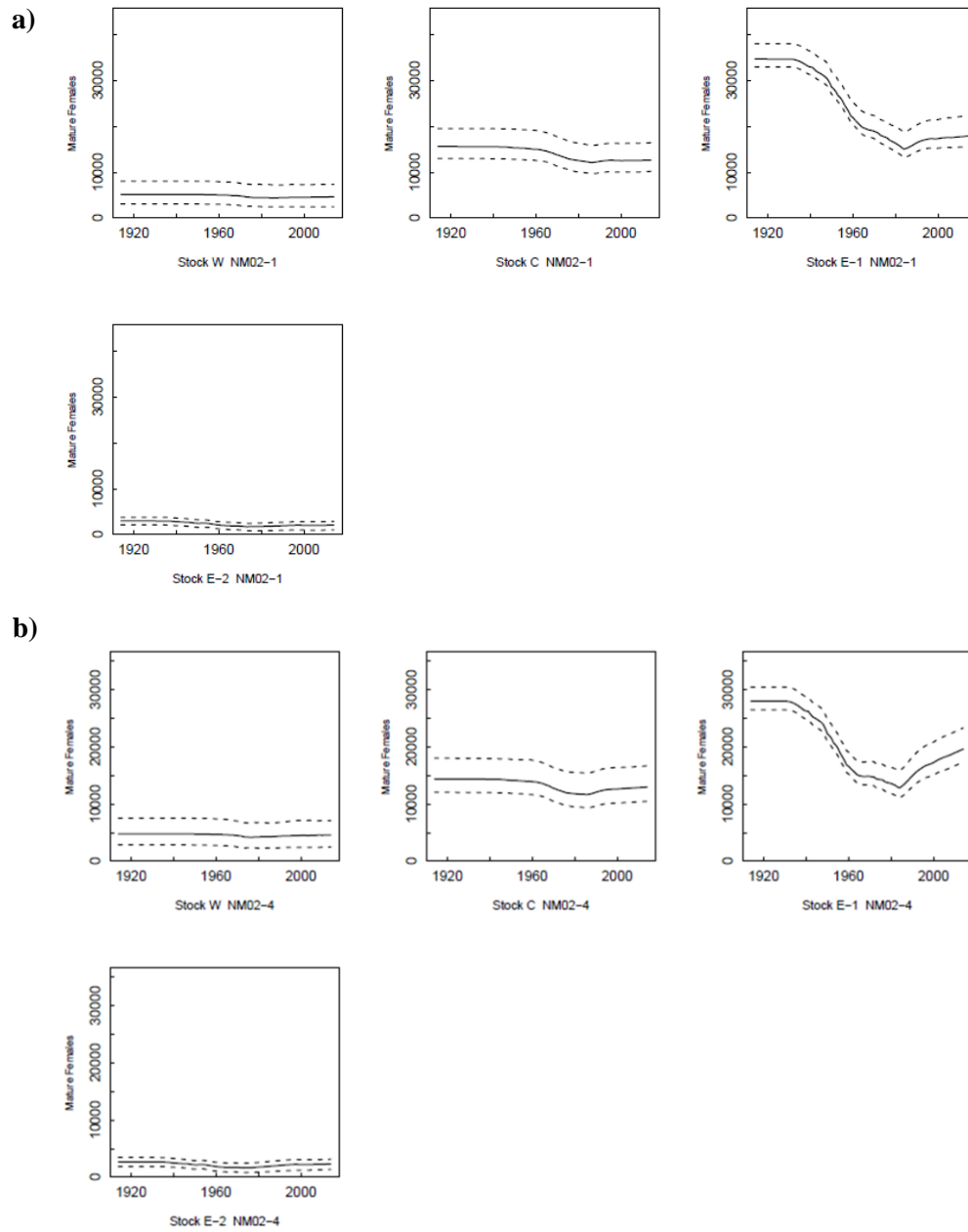


Fig. 2. From IWC (2015) Annex D, Appendix 5. a) NM02-1 median and 90%ile on mature female population for $MSYR_{1+}=1\%$, b) NM02-4; median & 90%ile mature female populations for $MSYR_{mat}=4\%$ by (sub-)stock for North Atlantic common minke whales

Management

In the past, management for the eastern North Atlantic common minke whales has been based on application of a variant of the RMP. For the central North Atlantic advice has been provided by NAMMCO, more recently using the RMP. In the western North Atlantic, advice has been developed in the IWC SC standing WG on the AWMP, more recently using an interim Strike Limit Algorithm (SLA).

West “Medium area”

There is currently no whaling in the WC (see Fig. 1) *sub-area*.

The current IWC management advice for West Greenland (WG, see Fig. 1) common minke whales (164) is based on the interim AWMP procedure applied to the 2007 estimate of 16,100 (CV: 0.43) common minke whales off West Greenland. The IWC advice for the next block quota starting in 2018 is planned to be based a management procedure that has not yet been established, but is planned to be developed from the trial structure of the ongoing RMP *Implementation Review*. The development is thus dependent on the finalization of this *Review*, with the possibility of small scale adjustments (by the IWC AWMP group) to the West Greenland component to address details that may have been overlooked in this *Review*.

Central “Medium Area”

The NAMMCO SC previously agreed that implementation of the IWC to calculate catch limits provided an appropriate basis to address the Council’s requests for assessments and advice. The RMP can be applied at a “*sub-area*” level, or to combinations of such *sub-areas*. For the Central North Atlantic common minke whale population there are four such *sub-areas* (see Fig. 1): the Jan Mayen *sub-area* (CM), the Icelandic coastal *sub-area* (CIC) in which Icelandic catches would concentrate, the East Greenland *sub-area* (CG) and the Icelandic pelagic *sub-area* (CIP). In 2010 the assessment WG and subsequently the NAMMCO SC agreed to management advice for the CIC *sub-area*, based on the RMP CLA with level of 0.60. The CLA was run with two different tuning levels (0.60 and 0.72) and variable inclusion of the two most recent abundance estimates for 2007 and 2009. Based on this assessment the NAMMCO SC concluded that annual removal of up to 216 common minke whales from the CIC *sub-area* is safe and precautionary. The advice was considered conservative in the sense that it was based on the uncorrected, downward biased 2009 abundance estimate as well as the lower of the two accepted abundance estimates from 2007. Similarly, an annual removal of 121 common minke whales from the CM *sub-area* was given as safe and precautionary management advice (NAMMCO 2010 p. 30). In 2011, the advice was updated using corrected estimates from 2007 and 2009 and a catch of 60 common minke whales in 2010. These new catch limit calculations gave a recommended catch limit of 229 for the CIC *sub-area*.

The management advice for East Greenland (EG, see Fig. 1) has been developed in the IWC SC standing WG on the AWMP.

East “Medium Area”

For the IWC East *Medium Area* the IWC-SC agreed the abundance estimates (mid time point 2011) in 2014, and agreed that the genetic data showed that all common minke whales in this *Medium Area* could be regarded as belonging to one stock.

For precautionary reasons the IWC-SC agreed that the EN *sub-area* should continue to be regarded as a *Small Area*, but that the *sub-areas* EW, EB and ES should be combined in a new *Small Area*. The IWC-SC *Implementation Simulation Trials (ISTs)* for the North Atlantic Central and East *Medium Areas* showed acceptable performance for this structure. For these reasons management advice for common minke whales in the next six year period from 2016 for the East *Medium Area* should be based on the 2011 abundance estimates using RMP with *tuning level* 0.60 and with *catch cascading* between the two remaining *sub-areas*.

Management advice for the Central *Medium Area*

Table 1 summarises the NAMMCO SC’s management advice for the Central *Medium Area* in the past.

Table 1. NAMMCO SC management advice for Central North Atlantic common minke whales.

Year	Latest survey	CIC	Central	Source	Basis for Advice
1997	1987	185	292	SC6 (21/MC4)	Hitting-with-fixed-MSYR model
2003	2001	400	400	SC11	Hitter
2009	2007	200	200	SC15	Hitter
2010	2009	216	337	SC17	RMP-CLA
2011	2009	229	350	SC18	RMP-CLA

Elvarsson presented SC/22/AS/04, which is based on the IWC RMP, and provides catch limits for North Atlantic common minke whales in the Iceland coastal CIC *sub-area*. This advice follows from an analysis that is based on the same approach as used in SC/18/AS/05; the only new input information is updated catch data.

Based on SC/22/AS/04, the WG recommended that a catch limit of 224 common minke whales (based on the CIC management unit and a tuning level of 0.60) for common minke whales in the CIC *sub-area* is safe and precautionary, and that this advice should be considered valid for a maximum of 3 years (2016 — 2018). This is interim advice because the most recent abundance estimate is from 2009, and the WG reiterated its previous recommendation that 10 years is the longest period the approach applied could be used without a new abundance estimate becoming available. The WG also recognised that a survey had been carried out this past summer (2015), although the associated areal coverage was considered to be poor.

It should be noted that the catches in the CIC *sub-area* have in recent years been a small fraction of the total allowable catch, and although catch limits have been allocated to the CM *sub-area*, no whales have been taken there in recent years (since 2011).

Rationale

Although this WG recommends using the three *Medium Areas* as management units in the future, the WG agreed to use the CIC *sub-area* as the management unit for this short-term advice based on the reasons below.

- This can be viewed as a conservative approach because it focuses on this *sub-area* only, although recent genetic studies have shown that at least the whole Central *Medium Area* can be considered as a single stock. For example, after the drop in abundance in the Icelandic coastal *sub-area* (CIC) between the 2001 and 2007 surveys, the management advice was reduced from 400 to 200 common minke whales based on assessments using the Hitter approach (Table 1).
- The WG would prefer to apply the CLA to the whole Central *Medium Area*, but the most recent abundance survey was that in 2009 which covered only the CIC *sub-area*. To apply the RMP at the *Medium Area* level would mean that the most recent abundance estimate for that whole region is from 2007, and so already almost 10 years old.

The WG noted that a new abundance estimate is needed for the whole Central *Medium Area*.

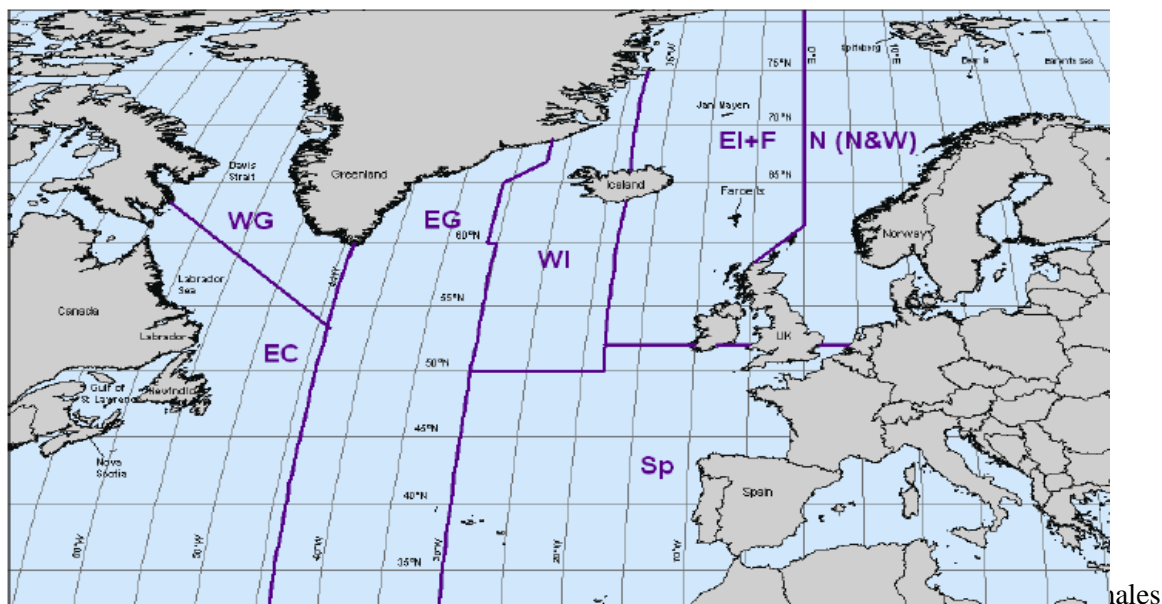
6. NORTH ATLANTIC FIN WHALE

In 2008 the NAMMCO SC was requested (R-3.1.7) to complete an assessment of fin whales in the North Atlantic, and also to include an estimation of sustainable catch levels in the Central North Atlantic.

At NAMMCO 23, Council endorsed an amendment to request R-3.1.7 to include the following additional text: “While long-term advice based on the outcome of the RMP *Implementation Reviews* (with 0.60 tuning level) is desirable, shorter term, interim advice may be necessary, depending on the progress within the IWC. This work should be completed before the annual meeting of the SC in 2015.”

Management Advice

At the 2010 NAMMCO fin whale assessment the WG agreed to use WI + EG as the unit for which a catch limit should be calculated (Fig. 3). The WG stated at that time that: “The IWC SC RMP trials also show that the [WI+EG management unit] would not lead to any serious conservation concern in the short to medium term (up to 10 years), even under the most pessimistic combination of stock-structure and MSYR value choices”. The WG applied the RMP on this basis, leading to the recommendation that an annual catch up to 155 fin whales could be taken in the WI *sub-area*.



Elvarsson presented SC/22/AS/04 which is based on the IWC RMP, and provides catch limits for North Atlantic fin whales in Iceland. This advice follows from an analysis that is based on the same approach as used in 2010; the only new input information is updated catch data.

Based on SC/22/AS/04, the WG **recommended** that a catch limit of 146 fin whales (based on the EG+WI management unit and a tuning level of 0.60) for fin whales that can be taken anywhere in the EG+WI region is safe and precautionary, and that this advice should be considered valid for a maximum of 2 years (2016 and 2017). This is interim advice because the most recent abundance estimate is from 2007, and the WG reiterated its previous recommendation that 10 years was the longest period the approach applied could be used without a new abundance estimate becoming available. The WG also recognised that a survey had been carried out this past summer (2015), and by this time next year a further agreed abundance estimate should be available.

The WG discussed that the catch limits advised at this meeting of 146 fin whales is lower than previous advice of 155 fin whales, even though the recent catches have been lower than the catch limits adopted and there is no new abundance estimate included in this new analysis. The reason for the slight decrease in this limit from the 2010 result, despite recent catches having been less than catch limits, is probably that for a resource estimated initially to be close to carrying capacity, the RMP gives catch limits that tend to decrease over time as catches lead to a decrease in abundance.

Rationale

As mentioned above, in 2010 the WG agreed to use the combined WI+EG *sub-areas* as the management unit. This WG meeting reiterated this recommendation and expanded upon the reasons below.

- Vikingsson et al. (2009, 2015) show a more homogeneous distribution of fin whales across the EG+WI *sub-areas* than in the past, suggesting that it is even less likely that there are different stocks in this region.
- The RMP was designed to be a robust procedure that can deal with distributional shifts within stocks, and recently observed shifts in distribution were within the boundaries of the EG+WI *sub-areas* (Vikingsson et al. 2009, 2015).

- Recent updated IWC SC *Implementation Simulation Trials (ISTs)* (with $MSYR_{1+}=1\%$), have shown poor fit of the data under Hypothesis IV (which treats the EG and WI *sub-areas* as feeding grounds for essentially separate stocks rendering their combination for catch limit computation problematic). This suggests that Hypothesis IV (with $MSYR_{1+}=1\%$) is of low plausibility.
- IWC SC development of these new *ISTs* has not led to the inclusion of any more conservative situations than encompassed by the previous *ISTs* (e.g., when recommendations to investigate density dependence were implemented).

Population trajectories from the *ISTs* (with the exception of Hypothesis IV) for the main stock exploited in the EG+WI sub-areas show a steady increase over recent decades to levels near or above that at which MSY would be obtained. Fig. 4 shows an example of such trajectories (Elvarsson pers. comm.; based on the *IST* for Hypothesis III).

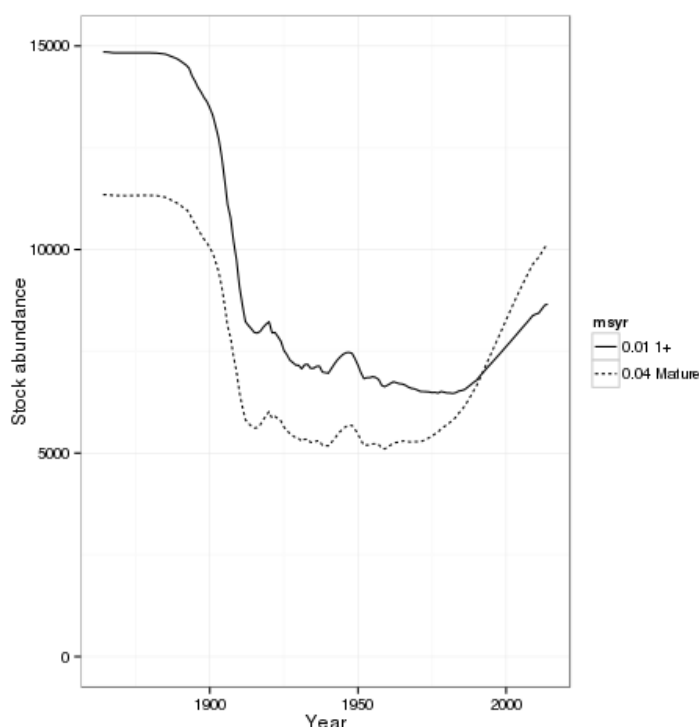


Fig. 4. Mature female population trajectories, estimated for the purposes of *Implementation Simulation Trials*, for the three central sub stocks combined for stock structure Hypothesis III for different MSYR rates.

Future Work

The WG discussed work that is currently underway, and may be informative for long-term advice within the next year or so.

- 1) A new abundance estimate is expected from this year's sightings survey (NASS2015), and will likely be accepted by the NAMMCO SC next year.

This new abundance estimate would provide new information to update the catch limit using the RMP.

The WG discussed an apparent problem with the realised effort for NASS2015 in that the observation effort in the fisheries surveys off East Greenland was mainly realized on transit legs along the shelf, due to unfavourable conditions at other times. Deleting this effort for a design based estimation approach will result in limited and unbalanced effort in the area; therefore some model-based approach may need to be considered.

- 2) Completion of IWC *IST* revision

This work is ongoing and an IWC workshop has been tentatively scheduled for February 2016. Completion of the IWC's work will be informative for long-term advice; however the WG recognises that this IWC work has been postponed in the past, and issues may yet arise that again delay completion of this work.

This *IST* revision could result in the formal rejection of Hypothesis IV (the most conservative hypothesis), and furthermore formal acceptance of Variant 3 (EG+WI+EIF) is possible, which could allow higher catch limits for harvests within the WI *sub-area*.

3) Revision of RMP with 0.6 tuning

The NAMMCO SC has requested that the RMP would be rerun with 0.6 tuning (NAMMCO 2010). These runs are conditional on the completion of the IWC *IST* revision. At the time these runs are performed it was suggested that two issues may need to be addressed:

- The CLA may need to be recalibrated as recently the minimum MSYR for trials has been revised. Previously the RMP-CLA used in the RMP has been tuned with respect to an MSYR of 1% for the mature population, but recently the IWC SC agreed to change the minimum MSYR to 1% on 1+ population.
- Acceptability of the management variants may need to be revised. Currently the *ISTs* consider threshold levels based on equivalent single stock trials (based on the T1-D1 trial) where the lower 5% quantiles of the final and minimum depletion levels when the CLA is applied with 0.6 and 0.72 tuning define the boundaries between unacceptable, borderline, and acceptable.

4) Results on research into stock structure.

Work is currently underway on genetics and tagging studies to inform further on stock structure.

Iceland is currently investigating genetics to identify close kin relationships. There are plans for some analyses to be available for the 2016 IWC SC meeting. A potential problem with these analyses is that the majority of the samples have been taken on the Icelandic whaling grounds, so that their distribution is limited and it would be hard to distinguish between potential stocks. Iceland is working on obtaining samples from Norway and Greenland, both from catches and biopsies. Biopsies will be very useful particularly because they come from a wider geographical area. If the genetics detects close relations present on both sides of the EG/WI boundary, it may be possible to reject the two stock hypothesis (Hypothesis IV) for this region.

Satellite tagging is also ongoing; however results are not expected within the next couple of years.

7. NORTH ATLANTIC HUMPBACK WHALE

The NAMMCO SC last reviewed the status of the West Greenland humpback whales in 2010. At that time, the SC applied the "interim SLA" to the most recent abundance estimate from 2007 to conclude that an annual catch of 20 whales was safe, and that this level of catch would allow the population to increase.

Within the IWC, management advice for humpback whales off West Greenland has been provided by the SC, which agreed on a final AWMP *SLA* for this stock in 2014. This NAMMCO WG endorsed this *SLA* as the best current basis for providing management advice for West Greenland humpback whales, as well as the current advice of up to 10 strikes per year requested by Greenland (within the IWC system) as being safe. This WG discussed but did not come to a conclusion on whether NAMMCO (if in a position to provide advice to Greenland) should consider the impact that the IWC's *Needs Statement* has on the quotas given by the *SLA*, considering that it is a component of the *SLA* procedure.

This advice applies up to and including 2017, and with an expected new abundance estimate from the NASS2015, a new calculation to provide advice should be straightforward.

8. NEXT NAMMCO SC WG ON ASSESSMENT – PREPARATION

The WG recommends that it meet again when abundance estimates are available from NASS2015 to provide updated advice. One possibility is to hold a joint meeting with Abundance Estimates WG.

The WG requires direction on for which species/areas further advice is wanted, noting the Council's wish to avoid duplication of work between the IWC and NAMMCO SCs.

The WG notes the following as necessary preparatory work for the next meeting:

- 1) Updated abundance estimates
- 2) Conduct of simulation trials of CLA re-calibration described for fin and minke whales

The WG noted that catch limit calculations could be conducted within the meeting.

9. OTHER BUSINESS

No other business was discussed.

10. ADOPTION OF THE REPORT

The content of the report was adopted during the meeting at 1:55pm on 7 October 2015, and in final editorial form by correspondence on 4 November 2015.

The WG thanked the Chair for his able chairmanship, and the invited experts for their hard work.

References

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Appendix 1 - Agenda

1. OPENING REMARKS
2. ADOPTION OF THE AGENDA
3. APPOINTMENT OF RAPPORTEUR
4. REVIEW OF AVAILABLE DOCUMENTS AND REPORTS
5. NORTH ATLANTIC COMMON MINKE WHALE
 - Background
 - Assessments
 - Management
 - Management advice for the central medium area
6. NORTH ATLANTIC FIN WHALE
 - Management
 - Future work
7. NORTH ATLANTIC HUMPBACK WHALE
8. NEXT NAMMCO SC WG ON ASSESSMENT – PREPARATION
9. OTHER BUSINESS
10. ADOPTION OF THE REPORT

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ANNEX 2 – Report of the meeting of the NAMMCO/JCNB

**NAMMCO SCIENTIFIC COMMITTEE WORKING GROUP ON THE POPULATION STATUS OF
NARWHAL AND BELUGA IN THE NORTH ATLANTIC**

And the

**CANADA/GREENLAND JOINT COMMISSION ON CONSERVATION AND MANAGEMENT OF
NARWHAL AND BELUGA SCIENTIFIC WORKING GROUP**

Ottawa, Canada, 11-13 March 2015

EXECUTIVE SUMMARY

A Joint Meeting of the NAMMCO Scientific Committee Working Group on the Population Status of Narwhal and Beluga in the North Atlantic and the Canada/Greenland Joint Commission on Conservation and Management of Narwhal and Beluga Scientific Working Group met in Ottawa, Canada, during 11-13 March 2015. The group reviewed new information on the biology of narwhals and belugas, updated the assessments and catch advice based on new information, and discussed the development and application of the Catch Allocation Model developed by the Catch Allocation Sub-Group.

NARWHALS

The JWG reviewed papers on narwhal biology, including studies on dietary differences based on stable isotopes, differences in mating systems between narwhals and belugas, comparison of diving behaviour between the three main populations, and passive acoustic monitoring of narwhals in Scott Inlet (Nunavut). Information in these papers were not used to update the assessment and advice at this meeting, but contribute to the overall knowledge of narwhal biology.

Catch Statistics and Struck and Lost

Information on catch statistics and struck and lost was presented from both Greenland and Canada.

Greenland presented a time series that provides realistic catch levels from West Greenland during 1862-2014, which was constructed with catches split into hunting grounds and corrected for under-reporting detected from purchases of mattak (low option), for periods without catch records (medium option) and from rates of killed-but-lost whales (high option). Struck and lost rates have been estimated using factors such as community, season, hunting method, and these estimates are included in the catch history that is used in the assessment model.

Canada presented catch statistics and a summary of the process of management advice in Canada. The catch statistics provided by Canada have not been split by summering stocks or struck and lost rates by communities. For the purposes of this meeting, a single value of 1.28 was multiplied by the raw landed catch to estimate the total removals.

The JWG reiterated the recommendation for Canada to provide corrected catch statistics to include in the assessments, including historical catches which are corrected for estimates of struck and lost that are based on factors such as the community, hunting methods, and season, rather than applying a uniform stuck and lost rate to all of the data. The JWG noted that ideally there would be monitoring programmes occasionally for struck and lost that could be used to update the values but recognised that there are no plans for this in the near future.

Surveys and Abundance

The JWG reviewed new correction factors for availability of narwhals during surveys based on satellite tagged narwhals (Watt et al. 2015). The JWG identified potential technical problems with the satellite tags that the authors agreed to review before the next meeting. The JWG agreed to use the new correction factors in the current assessment, and pending the outcome of the review of the possible technical problems.

Abundance estimates were presented from the High Arctic Cetacean Survey that was conducted in Canada in August 2013. The details of the survey will be discussed at the next JWG meeting when working papers are available.

New abundance estimates for narwhals in Melville Bay (one of the two summering areas in West Greenland) and East Baffin Bay based on aerial surveys were presented and these estimates of 2,983 narwhals (cv=0.39; 95% CI 1,452-6,127) and 3,091 (cv=0.50; 95% CI 1,228-7,783) in 2012 and 2014 were accepted by the JWG for use in the assessment.

An abundance estimate of narwhals in the North Water in winter was also presented, however, while these results can be used as information on winter distribution, these abundance estimates are not used in the assessment. The results do provide information suggesting a large number of narwhals use the North Water polynya in late winter and are available to move north, east, and west into summer aggregations areas: Jones Sound-Norwegian Bay, Inglefield Bredning, and Smith Sound.

Catch Allocation Model

Recognizing that the narwhals hunted in different regions cannot easily be attributed to their summering aggregation based on genetics or other stock identity information, the JWG tasked a sub-group to develop a model that includes the sum of all information that is available including telemetry movements, all survey abundance estimates, and historical catch data.

The Catch Allocation sub-group of the NAMMCO-JCNB Joint Scientific Working Group (JWGsub) met 10–12 March 2014 in Copenhagen, Denmark, and again in Ottawa, Canada 9-10 March 2015.

The Terms of Reference for this meeting were to:

- review information on distribution, movements and harvest locations of narwhal;
- develop an allocation model that will provide a mechanism for assigning harvested animals to all summer stocks based on existing data;
- specify and quantify exchange rates between aggregations and stocks;
- identify and quantify uncertainty in the allocation model and determine implications for management; and
- recommend future work to resolve uncertainties within the model structure.

The main purpose for these meetings was to develop a model for catch allocations for the Baffin Bay narwhal population that is shared by Canada and Greenland, but not to decide on the sustainability and/or provide advice on the actual quotas. The JWGsub reviewed the available data on takes and migratory movements of narwhals and determined that in some areas different stocks of narwhals were available to hunters in different seasons. Data from satellite tags attached to narwhal in summer aggregations and expert opinion was used to determine which summer aggregations were available to hunters in villages and the timing of that availability.

Hunts were divided into four seasons to correspond with the spring and fall migrations the summer aggregation period and the overwintering areas. A total of 24 seasonal hunts were identified to be allocated among the 8 summer aggregations. To do this an allocation matrix with 24 rows by 8 columns was devised. The eight columns were the individual summer aggregations of Smith Sound, Jones Sound, Inglefield Bredning, Melville Bay, Somerset Island, Admiralty Inlet, Eclipse Sound, and East Baffin Island. The 24 rows represented 24 hunts in 10 regions and some regions hunts were divided by season.

Thus for each summer aggregation and hunt there is a cell in the matrix, and the matrix is devised so that when multiplied by a number of removals, the resulting number will determine the total removals from each summer aggregation. The cells in the matrix were determined using the tag data, or when no tag data was available, then expert opinion and the relative abundance of each summer aggregation. The tag data determined the fraction of the summer aggregation that was available to a hunt, which was multiplied by the size of the stock to determine the numbers from each summer aggregation exposed to each hunt. These were then divided by the total number of whales available to a hunt to determine the proportion of the hunt that came from the summer aggregation. The JWGsub identified a number of points of uncertainty and thus developed a method

for testing the sensitivity of the allocation to data uncertainty as well as stochastic variation of the matrix from year to year.

The JWG recommended that the remaining tasks are now the responsibility of the full JWG. Therefore, the Catch Allocation subgroup work was considered completed.

Metapopulation Model

A metapopulation model was presented that combined the catch allocation model for narwhals in East Canada and West Greenland with Bayesian population modelling of the eight summer aggregations of narwhals in the region. The catch allocation model allocates the catches in different hunting areas and seasons to the different summer aggregations, and the population models analyses the impact of these catches on the population dynamics of the eight narwhal aggregations. The metapopulation model uses population trajectories and catch histories from 1970 to 2014 to estimate the catches taken from the different summer aggregations during this period.

The population dynamics that are estimated for the different summer aggregations from these catch histories were presented. Some of the summer aggregations, like those in Smith and Jones Sound, have very low catches that have little affect the dynamics, while the narwhal aggregation in Melville Bay is clearly influenced by the historical takes. The narwhal aggregation around Somerset Island may have an increasing trend, and those in Inglefield Bredning, Admiralty Inlet, Eclipse Sound and East Baffin Island appears relatively stable. The model estimates that nearly all the aggregations are above the maximum sustainable yield level (MSYL) where slightly decreasing trends usually are of no concern. The exceptions are Inglefield Bredning and Melville Bay. Both of these aggregations are estimated to be depleted to levels below the MSYL, implying that future harvest levels should be set to ensure an increasing number of narwhals in these summering areas.

For situations where stocks may be below or above the MSYL, realistic management objectives could reflect allowable takes that ensures that stocks below the MSYL are increasing towards the MSYL, while the takes from stocks above the MSYL level should be smaller than the maximum sustainable yield (MSY), e.g., smaller than 90% of the MSY. Given such a management objective, the JWG reviewed the estimated annual takes from the different summering aggregations over the next five years that allows this management objective to be fulfilled with a probability from 0.5 to 0.95.

The take of narwhals from the different summering aggregations cannot be managed by consideration of summering grounds exclusively because many narwhals are caught in other hunting areas at other times of the year (e.g., during migration). Instead, management limits for different hunts and season must be considered together.

The JWG reviewed two potential scenarios of takes and their relation to management objectives. In these scenarios, the average removals from 2009-2013 from Melville Bay did not meet the above management objective example of 70% probability of success and East Baffin did not meet 80%, thus the JWG **recommends** reducing the hunts that remove narwhals from these stocks. The JWG proposed an alternative using a simple approach to reallocation as an example of adjusting take limits to meet the management objectives. The JWG **recommends** using the catch allocation model with the assessment models to verify that allowable takes do not exceed acceptable risk levels.

While the model can be used to determine the risk of a particular harvest regime, the JWG **seeks further guidance** from the JCNB/NAMMCO on the management objectives.

East Greenland Assessment

The updated assessment suggests somewhat lower catch than the previous advice for the Ittoqqortormiit area. The JWG **recommends** this lower quota since the data that is available (2008) is now seven years old and consequently less reliable to represent the current status of the narwhals in that area. The JWG also **recommends** that a new survey be conducted in East Greenland.

The JWG discussed whether the East Greenland stocks should be considered depleted, stable or growing, information that would assist in setting management objectives.

Future Research

The JWG recommends that future research includes:

- 5) Aerial survey in East Greenland
- 6) More satellite tag and dive data from the stocks in West Greenland and Eastern Canada to obtain more information about movement between summer aggregations and information for availability bias for survey correction factors
- 7) Developing a model (e.g., “Hidden Markov”) to incorporate perception bias, which requires detailed dive cycle information

BELUGAS

The JWG reviewed new information on beluga biology including ageing using aspartic acid racemisation and fatty acids, and estimating weaning ages using stable isotopes. This information was not used in the assessments at this meeting.

Catch Statistics

Updated catch statistics from Greenland were presented. Catch levels in the past five decades are evaluated on the basis of official catch statistics, trade in mattak (whale skin), sampling of jaws and reports from local residents and other observers. Options are given for corrections of catch statistics based upon auxiliary statistics on trade of mattak, catches in previous decades for areas without reporting and on likely levels of loss rates in different hunting operations. Catches were also corrected for underreporting and struck and lost. The JWG approved the methods and the medium and high options are provided for the assessment model as correction options.

The group noted that in 2013 there were higher catches than usual in Upernavik. The reason for this is not known, however it may be informative to review the seismic activities that occurred in the region in 2013. It is possible that seismic activities could have driven the whales closer to shore, making them more susceptible to hunting. It is already known that belugas are easily scared into the coast, and also that the migration patterns of belugas are potentially affected by seismic activities.

Canada presented catch statistics and a summary of the process of management advice in Canada. The catches presented did not include struck and lost rates. The JWG agreed that there is a need to construct a table that better illustrates which catches are thought to be shared between Canada and Greenland. This table needs to go back to 1970 to be included in the assessment models.

Abundance

The JWG reviewed a new abundance estimate from eastern Davis Strait and Baffin Bay based on an aerial survey conducted in March-April 2012. The population remains depleted compared to historical levels (20,000 in ca 1980, probably previously even higher than that), but has levelled off after a catch quota was introduced (and thus catches reduced). The JWG agreed to accept the mark-recapture abundance estimate of 9,072 whales (CV=0.32, CI: 4,895-16,450).

A winter abundance in the North Water was presented. Similar to narwhals, this estimate is not used in the assessment, however it provides useful information on winter distribution.

Assessment Update

The JWG reviewed an update on the population assessment for belugas, which used recent abundance estimates and historical catches in an age-structured population model with density-regulated growth to perform Bayesian assessments of the beluga aggregation that winters off West Greenland. The model starts from a stable age-structure in 1970 under the assumption that the 1970-abundance was below the current carrying capacity, and it was applied with a high and low prior on adult survival.

The dynamics of the high survival model estimates a decline from 19,140 (90% CI:12,680-28,260) individuals in 1970 to a maximal depletion of 8,130 (90% CI:5,740-11,440) in 2004, and an increase to 11,420 (90% CI:6,370-17,850) individuals in 2020 (assuming yearly post 2014 catches of 294). The predicted change from a declining to an increasing population was caused by the introduction of quotas in Greenland, with annual

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catches in the order of 500 to 700 reduced to less than 200 after 2004. Given total annual removals of 320 individuals from 2015 to 2020, the low survival model estimates that there will be a 70% chance of an increasing population over the period.

The group discussed how the current analysis could allow higher catches even with a lower recent abundance estimate. The group concluded that the recent lower catches has allowed the population to increase and hence allows recommendations of higher catches. While the recent point abundance estimate is lower, it is not statistically different than the previous abundance estimate consequently the model considered the population to be stable or increasing.

Advice from the JWG

Reiteration of Past Advice

The JWG **reiterates** the previous advice from 2005 and 2012 about seasonal closures. The following seasonal closures are **recommended**:

- Northern (Uummannaq, Upernavik and Qaanaaq): June through August
- Central (Disko Bay): June through October
- Southern (South of Kangaatsiaq): May through October.
- For the area south of 65°N, it is recommended that no harvesting of beluga be allowed at any time.

The function of these closures is to protect the few belugas that may remain from historical summer aggregations in Greenland, and to allow for the possibility of reestablishment of the aggregations.

No specific advice was given on the North Water, noting that the removals remain at a low level relative to the population size derived from the 2009-2010 and 2014 surveys in the North Water and around Somerset Island in 1996, and assuming that future catches remain at low levels.

New Advice

With the new accepted abundance estimate for belugas in West Greenland in 2012, the JWG provided updated advice provided in Table 5 in the Main Report.

Other Business

The JWG noted that traditional knowledge is used whenever relevant. The JWG also discussed issues related to the impact of human-made noise. A Symposium on the impacts of human disturbance on arctic marine mammals planned for fall 2015, convened by NAMMCO. A summary report from this Symposium will likely be available at the next JWG meeting.

The JWG also agreed that at the next meeting, the group should discuss guidelines for giving advice in data-poor situations.

The JWG adopted the draft ROP which will be sent to the JCNB and NAMMCO Council for approval (Appendix 5 of the Main Report).

MAIN REPORT

1. OPENING REMARKS

NAMMCO Chair Roderick Hobbs welcomed the participants (Appendix 1) to the meeting. Steve Ferguson agreed to chair for the JCNB, recognizing that this will be his third meeting as chair, where in the past JCNB chairs have served for two meetings. The JWG selected Rikke Guldberg Hansen as the co-chair for the JCNB at the next meeting and NAMMCO will notify the NAMMCO SC that we have invited Roderick Hobbs to continue as the NAMMCO Chair.

2. ADOPTION OF JOINT AGENDA

The agenda was adopted with minor changes.

3. APPOINTMENT OF RAPORTEURS

Prewitt agreed to rapporteur with support of meeting participants.

4. REVIEW OF AVAILABLE DOCUMENTS

Chair Hobbs reviewed the available documents (Appendix 2).

5. NARWHALS

5.1 Stock structure

5.1.1 Genetic information

There was no new information on genetics.

5.1.2 Satellite tracking

No new satellite tracking information was available.

5.1.3 Other information

Dietary differences by stable isotope analysis

Watt presented on differences in diets by population based on stable isotopes. Narwhals (*Monodon monoceros*) are sentinel species in the Arctic and to investigate dietary differences, both spatially among three narwhal populations, and temporally within two of the populations, we examined diet using fatty acids, $\delta^{15}\text{N}$, and $\delta^{13}\text{C}$. Stable isotope analysis revealed the three populations have distinct $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values that are not expected based on geographic differences and that males in all populations had significantly higher $\delta^{13}\text{C}$. Stable isotope mixing models revealed narwhals in East Greenland (EG) forage more on pelagic prey, while those in Northern Hudson Bay (NHB) typically forage in the benthos. Temporal changes in diet were investigated over 30 years in the Canadian narwhal populations (NHB and Baffin Bay (BB)) with greater changes predicted for the more southern population (NHB). In NHB, $\delta^{15}\text{N}$ significantly increased, $\delta^{13}\text{C}$ displayed a parabolic trend, and fatty acids gradually shifted, albeit not significantly, over time. $\delta^{15}\text{N}$ was stable, $\delta^{13}\text{C}$ decreased, and fatty acids significantly changed over time in BB. Stable isotope mixing models indicated a dietary reduction in capelin (*Mallotus villosus*) and increase in Greenland halibut (*Reinhardtius hippoglossoides*) from 1994-2000 to 2006-2011 in BB, while capelin was an important dietary component for narwhals in NHB in recent years (2006-2011). These dietary changes may be attributed to changes in sea ice and narwhal migration.

Discussion by JWG

Samples were skin and muscle that came from hunted animals in August and September. The prey is changing, but these samples were compared to prey from around the timeframe. The JWG has discussed using SI to delineate stocks in the past and this information is interesting for the JWG to monitor future results.

5.2 Biological parameters

5.2.1 Age estimation

No new information was available.

5.2.2 Reproductive rates

No new information was available.

5.2.3 Population Dynamics

Beluga and Narwhal mating systems

Ferguson presented Kelley et al. (2014) which looked at mating systems in narwhal and beluga (*Delphinapterus leucas*). Narwhal and beluga whales are important species to Arctic ecosystems, including subsistence hunting by Inuit, and little is understood about their mating ecology. Reproductive tract metrics vary across species in relation to mating strategy, and have been used to infer mating ecology. Reproductive tracts from beluga and narwhal were collected between 1997 and 2008 from five beluga stocks and two narwhal stocks across the Canadian Arctic. Tract length for males and females, relative testes mass for males, and tusk length for male narwhal were measured. We assessed variation relative to species, body size, stock, maturity, and season. Beluga whales from the High Arctic were the heaviest, followed by Beaufort Sea, then Cumberland Sound, and smallest whales came from Western and Eastern Hudson Bay stocks. Significant variation was found in testes mass across month and stock for beluga, and no significant difference between stock or date of harvest for narwhal. Beluga had significantly larger testes relative to body size than narwhal, suggesting they were more promiscuous than narwhal. A significant relationship was found between narwhal tusk length and testes mass, indicating the tusk may be important in female mate choice. No significant differences were found between narwhal and beluga reproductive tract length for males or females. The mating systems suggested for narwhal and belugas by our results suggests that the two species may respond differently to climate change.

Discussion by the JWG

The group discussed whether sexual dimorphism was considered, i.e., how different are males versus females in narwhal and belugas, given the different mating strategies of each whale.

5.2.4 Diving behaviour

Diving behaviour in Northern Hudson Bay, East Greenland and Baffin Bay

Watt presented paper NAMMCO/SC/22-JCNB/SWG/2015-JWG/07 which analysed dive behaviour in the three populations of narwhals in the world; the Northern Hudson Bay (NHB), East Greenland (EG), and Baffin Bay (BB) populations. Thirty-four narwhals from these populations were equipped with satellite-linked transmitters in order to evaluate the total number of dives and time spent in pre-defined depth categories. Repeated-measures ANOVAs found narwhals from EG made significantly more dives and spent more time in the mid-water column compared to other populations. NHB narwhals made more dives in the deep zone than in the mid-water region. BB narwhals spent time and made most dives within the upper water column and the deep zone, which suggests deep-dwelling prey may contribute substantially to their diet. Within the BB and EG populations, there were sex-specific differences in time spent at depth and we identified seasonal changes in diving for all populations. This is the first study to compare dive behaviour in all three of the world's narwhal populations.

Discussion of the JWG

Dive behaviours between EG and BB are likely due to differences in foraging behaviour even though depths are similar in these areas.

The seasons used in this study were based on Dietz et al. (2001) which defines summer as the end of July to the end of September. The group suggested that the data could be reanalysed using different definitions of season, especially using a summer season that ends before the fall migration begins (as recommended in the Catch Allocation JWG_{sub} meeting). It is possible that changing the definition of summer season in the Watt et al. study presented here could change some of the results since the summer season currently may encompass some migratory behaviour.

The group discussed whether differences in dive behaviour could be attributed to migration or feeding based on displacement data.

It was noted that by considering individual dives as samples, the standard errors for the averages were very small and consequently small differences that were statistically significant may not be biologically significant. Previous studies using stable isotopes showed differences between these narwhal populations, and the diving study was aimed at looking to see if the dive behaviour supported this.

5.2.5 Other information.

Passive Acoustic Monitoring

Marcoux presented information on a passive acoustic monitoring study in Scott Inlet. An acoustic recorder was deployed in Scott Inlet (Nunavut) to monitor the presence of narwhals and other marine mammals. Twelve percent of the files were manually inspected to detect sounds from marine mammals. An automated detector was applied to detect clicks from narwhals. The detection of marine mammal sounds was highly influenced by the presence of ice. We discussed the potential to estimate narwhal densities from the number of clicks, the limitations of this technique and future work required.

Discussion by the JWG

Acoustic tags in Greenland have shown that individual animals can be quiet for 24 hrs or more and it demonstrates the need for tags that can record for several days.

Marcoux et al. have not yet investigated whether any of the recorders picked up seismic noise.

5.3 Catch statistics

5.3.1 Canadian and Greenlandic catch statistics

Greenland

Heide-Jørgensen presented information and statistics including some trade statistics on catches of narwhals in Greenland since 1862 (NAMMCO/SC/22-JCNB/SWG/2015-JWG/06). Detailed statistics split by hunting grounds are missing for most of the years. For the northernmost area, the municipality of Qaanaaq, only sporadic reporting exists. Based on statistics from the most recent three decades a time series is constructed for West Greenland with catches split into hunting grounds and corrected for under-reporting detected from purchases of mattak (low option), for periods without catch records (medium option) and from rates of killed-but-lost whales (high option). This reveals a time series of somewhat realistic catch levels from 1862 through 2014. Since 1993, catches have declined in West Greenland especially in Uummannaq and Disko Bay where the decline is significant. In East Greenland there has been an increase of 5% per year since 1993.

Discussion by the JWG

Overall increases in the harvest have been seen in East Greenland, but it is variable. The methods presented here have been reviewed by the JWG in the past, and this update is based on information that is provided by the government of Greenland. The JWG noted that there could be some under-reporting but the magnitude is unknown, and this is considered and adjusted for in the high option for the early years.

Canada

Ferguson presented paper NAMMCO/SC/22-JCNB/SWG/2015-JWG/12 which provided catch data and a summary of the process of management advice in Canada. Canadian narwhal and beluga fisheries are regulated by the Fisheries Act (R.S., 1985, c. F-14) and regulations made pursuant to it, including the Fishery (General) Regulations and the Marine Mammal Regulations. In the Nunavut Settlement Area, these fisheries are co-managed by Fisheries and Oceans Canada (DFO), the Nunavut Wildlife Management Board (NWMB), Regional Wildlife Organisations (RWOs), and Hunter and Trapper Organisations (HTOs), and Nunavut Tunngavik Inc. (NTI) in accordance with the Nunavut Land Claims Agreement (NLCA), and the Fisheries Act. Where an inconsistency exists between federal statutes and the NLCA, the Agreement shall prevail to the extent of the inconsistency. The NWMB is the main instrument of wildlife management in the Nunavut Settlement Area; however, the federal government retains ultimate responsibility for wildlife management.

Discussion by the JWG

The Integrated Fisheries Management Plan is a new approach that included information on movements among summer stocks, rather than just being based on the hunt from each community.

The JWG acknowledged that these were raw catch data and had not been adjusted for struck and lost or under-reporting. However, an average rate of 1.28 was applied to these Canadian catch data to represent struck and lost in the data provided to the catch allocation model (described below in section 5.5.1).

5.3.2 Struck and lost

Greenland

Hunters are required to report struck and lost but it is likely that there is some under-reporting of lost animals. For narwhal and beluga, the quota is set as a strike limit, which includes both the landed take and the reported struck and lost. In Greenland, hunters are not allowed to shoot before harpooning, and they are not allowed to shoot from the shore.

Struck and lost rates have been estimated using factors such as community, season, hunting method, and these estimates are included in the catch history that is used in the assessment model.

Canada

It is known that the struck and lost rate likely varies by factors such as community, season, hunting method, and experience of the hunter. For example, some communities use a harpoon before shooting, which probably lowers their struck and lost rate, whereas a floe edge hunt may have higher struck and lost. For the purpose of the allocation model, a single value of 1.28 was multiplied by the raw landed catch to estimate the total removals.

Discussion of JWG

The catch statistics provided by Canada have not been split by summering stocks or struck and lost rates by communities. It would be informative for the JWG to have this information provided as a working paper with text on the methods.

The JWG reiterates the recommendation for Canada to provide corrected catch statistics to include in the assessments, including historical catches which are corrected for estimates of struck and lost that are based on factors such as the community, hunting methods, and season, rather than applying a uniform struck and lost rate to all of the data. The JWG noted that ideally there would be monitoring programmes occasionally for struck and lost that could be used to update the values but recognised that there are no plans for this in the near future. The JWG agreed to use the analysis of struck and lost data that is ongoing in Canada, plus incorporate observations of locations and hunting methods where the rates may differ. These estimates will be presented at the next JWG meeting. The JWG agreed that the development of the Catch Allocation model does not need to be delayed to wait for these estimates of struck and lost, however the recent data, once analysed, should be incorporated into the Catch Allocation model following a review by the JWG.

5.3.3 Ice entrapments

Ice entrapments are natural events, but catches from known ice entrapments are included in the catch history that is used in the allocation model.

More discussion of ice entrapments (and their possible causes) are included under Item 8.

5.4 Abundance

5.4.1 Recent estimates

Instantaneous correction factors for narwhal availability

Watt et al. (2015) provided information on correction factors based on narwhal dive behaviour. Narwhals (n = 24) equipped with satellite tags near the communities of Arctic Bay and Pond Inlet, Nunavut from 2009-2012 provided information on the time narwhals spend at different depths. Aerial surveys to estimate narwhal abundance were conducted in August 2013 and require incorporation of an availability bias correction to account for narwhals that may have been present but were either not visible to observers, or not distinguishable from beluga whales. An instantaneous availability correction factor used to correct aerial surveys can be estimated from the proportion of time diving animals spend near the surface where they can be detected and identified. Narwhals diving deeper than 2 m are not distinguishable from an aircraft in clear waters, while narwhals in highly turbid waters, such as that found in fiords where glacial runoff enters, may not be distinguishable at >1 m depths. The proportion of time narwhals spent at 0-1 m, and 0-2 m depths was analysed in a mixed effect model with whale as a random variable and period of August (mid versus late), time of day (day or night), sex, and area of tagging as fixed factors. The chosen model included no variables for the 0-1 m bin and period of August for the 0-2 m bin. Tagged narwhals spent 20.4 ± 0.78 % of their time in the 0-1 m bin in August and we recommend an instantaneous availability correction of 4.90 (± 0.187) for the 2013 survey in regions with highly turbid waters where visibility may be limited. Narwhals spent 31.4 ± 1.06 % of their time in the 0-2 m bin in mid-August and we recommend an instantaneous correction of 3.18 (± 0.107) for 2013 survey strata occurring in clear waters.

Discussion of the JWG

The JWG suggested that issues with drift in the pressure transducer should be investigated. Greenland has information that drift of the pressure transducer caused large portions of their data to be discarded. The authors recognise that this could be an issue and will investigate further.

The JWG agreed to proceed with the correction factors produced from this study, pending the results of the review of the drift issue. This will be reviewed at the next meeting of the JWG.

High Arctic Cetacean Survey

The Department of Fisheries and Oceans conducted a High Arctic survey in August 2013 to estimate abundance of the six Canadian Baffin Bay narwhal summer stocks. Narwhal abundance was estimated using a double-platform aerial survey. The survey was flown at an altitude of 1,000 feet (305 m) and a target speed of 100 knots (185 km/h) using three deHavilland Twin Otter 300 aircraft, each equipped with four bubble windows on the sides and a large belly window used for cameras. The survey was designed to cover the largest possible proportion of the summering areas of Baffin Bay stocks while at the same time improving on the precision of past estimates. Each stock range was divided in several strata, based on geographic boundaries as well as presumed densities of narwhals inferred from past surveys. Distance sampling methods were used to estimate detection probability away from the track line. A mark-recapture model was used on the sighting data from pairs of observers on each side of the aircraft to correct for perception bias. Abundance in fiords was estimated using density spatial modelling to account for their complex shape and uneven coverage. Estimates were corrected for availability bias using an updated analysis of satellite-linked time depth recorders transmitting information on the diving behaviour of narwhals in August. Fully corrected abundance estimates were 12,694 (CV 33%) for the Jones Sound stock, 16,360 (CV 65%) for the Smith Sound stock, 49,768 (CV 20%) for the Somerset Island stock, 35,043 (CV 42%) for the Admiralty Inlet stock, 10,489 (CV 24%) for the Eclipse Sound stock, and 17,555 (35%) for the East Baffin Island stock. No previous survey had counted all of the Canadian Baffin Bay narwhal stocks during one summer. Major sources of uncertainty include high levels of clustering in some areas as well as the difficulty of identifying duplicate sightings between observers viewing large aggregations of narwhal.

Discussion by the JWG

The details of the survey will be reviewed at the next JWG meeting when working papers are available. As mentioned above, there is some concern about the availability correction factor due to the transducer drift issue, which will be investigated before the next meeting.

The group noted that the western part of Lancaster Sound was not covered by the survey. Considering other changes in behaviour, it is possible that some narwhals could have been in that area. No survey of narwhal in Lancaster Sound is planned since previous surveys of this area in summer (August) did not observe many narwhal. This region is considered a migration corridor between winter and summer ranges and narwhal occur there only briefly while in transit.

All of the observations of narwhals on East Baffin Island occurred in fjords with opaque water conditions. Due to the opacity of the water here, a correction factor based on the 0-1 m depth bin was used (i.e., it was assumed that observers could not spot and identify narwhals that swam deeper than 1 m), whereas non-fjord areas as well as fjords in other strata (e.g., Admiralty Inlet, Eclipse Sound, and Ellesmere Island) all used the 0-2 m bin. In other words, water conditions in fjords other than the East Baffin stratum were not considered opaque enough to justify using a different correction factor.

The group discussed whether a correction factor should be developed just for animals at the surface, however the data on the dive cycle is needed to be able to do this. A Hidden Markov model may be considered for future analysis.

Abundance in Melville Bay

Hansen presented a recent abundance estimate from Melville Bay in the summer (NAMMCO/SC/22-JCNB/SWG/2015-JWG/14). Narwhals have one of their two West Greenland summering grounds in the Melville Bay. Aerial surveys of the abundance of narwhals in Melville Bay were conducted in late August 2012 and 2014. Three analytical models were deployed to derive fully corrected abundance estimates. In 2012 the perception bias estimation was augmented with samples from two other identical surveys conducted in

August and September 2012. A mark-recapture distance sampling (MRDS) model provided estimates corrected for at-surface availability of 22% ($cv=0.09$) of 2,983 narwhals ($cv=0.39$; 95% CI 1,452-6,127) and 3,091 ($cv=0.50$; 95% CI 1,228-7,783) in 2012 and 2014, respectively. A Hidden Markov line transect model (HMLTM) that takes the time the whales are in view of the observers into account provided estimates of 741 ($cv=0.44$, 95% CI 324-1651) and 1710 ($cv=0.39$, 95% CI 422-3,064) for 2012 and 2014, respectively. The data on availability used in the HMLTM were based on data on duration of surfacings and submergence above and below 2 m depth with an overall availability of 39% ($cv=0.02$) collected from narwhals in East Greenland. When using dive cycle parameters scaled to a total availability of 20% ($cv=0.02$) the HMLTM estimates increased to 1391 ($cv=0.41$, 95% CI 564-3144) and 3164 ($cv=0.41$, 95% CI 859-5,767) in 2012 and 2014, respectively.

A CDS analysis with an availability correction factor of 39% gives an abundance estimate of 904 narwhals ($cv=0.38$, 95% CI 427-1,913) and 2,008 ($cv=0.43$, 95% CI 843-4,785) in 2012 and 2014, respectively. The point estimates is reduced to 820 and 1,543 if the correction factor of Laake et al. (1997) is used. The CDS analysis with an availability correction factor of 22% gives an estimate of abundance of 1,603 narwhals ($cv=0.38$, 95% CI 757-3,395) and 3,563 ($cv=0.43$, 95% CI 1,495-8,488) in 2012 and 2014, respectively.

The main difference between the four estimates are: 1) The MRDS model utilizes data from two similar surveys in (2012) in the detection process estimation. 2) The MRDS model does not correct for the non-instantaneous availability of the whales. 3) The HMLTM corrects for non-instantaneous availability but not for perception bias. 4) The CDS does not include corrections for perception bias and is only partly corrected for non-instantaneous availability. The animals were within detectable forward distance of about 4% and 8% of their mean dive cycle length in 2012 and 2014, respectively, and this implies that the 2012-survey is 'more instantaneous' than the 2014-survey.

Discussion by the JWG

The group noted that the three surveys conducted in 2012 cannot be combined because they occurred during different times during the year and the last survey was conducted when the migration had already begun. In addition, the three surveys were designed to occur before, during and after seismic surveys.

The Hidden Markov model is useful for non-instantaneous surveys, although it does not currently correct for the perception bias, and to do so requires very detailed information on the dive profile. When the Hidden Markov model was used, the dive cycle data was obtained from a time-depth recorder (Acousonde™) deployed on one narwhal in East Greenland in 2013. There is a problem of the pressure transducer not giving an accurate time-at-surface due to issues with the effect of temperature on the function of the transducer. One option is to take the average time around zero, however it is likely not precise enough. The authors are working towards applying a function to compensate for this.

The MRDS estimates corrected for availability were **accepted** by the JWG for use in the assessment.

Abundance in East Baffin Bay

Hansen presented the recent abundance estimate from East Baffin Bay (NAMMCO/SC/22-JCNB/SWG/2015-JWG/15). An aerial visual survey of the density and abundance of narwhals was conducted in the eastern part of Davis Strait and Baffin Bay in March-April 2012. The survey was conducted as a double platform aerial line transect survey, and sampled approximately 7,800 km of the total survey area of ca. 243,000 km². Two different analysis of sightings were applied; Hidden Markov line transect model (HMLTM) and mark-recapture distance sampling (MRDS). The HMLTM methods do not assume certain detection at perpendicular distance zero; they assume only certain detection of animals that are available (i.e. not too deep to be seen) at radial distance zero. The best model included Beaufort sea state as an explanatory variable and resulted in estimated narwhal abundance of 11,259 narwhals with ($cv=0.34$, 95% CI 4,390-20,568). However, this model fits the perpendicular distance data poorly. When the HMLTM model was fitted with an alternative availability model in which whales are estimated to be available 20% ($cv=0.02$) of the time, abundance estimates increased by 88% to 21,115 ($cv=0.35$, 95% CI 9,506- 39,416). The mark-recapture distance sampling (MRDS) estimator of individual abundance yielded an abundance estimate of 4,367 whales ($cv=0.39$, 95% CI 1,869-10,203). The time narwhals are estimated to be available in April in the survey area is 23.5% ($cv=0.32$) and when correcting the MRDS estimate with this correction factor, the estimate of animal abundance increases to 18,583 whales ($cv=0.50$, 95% CI 7,308-47,254).

Discussion by the JWG

The offshore strata was intended to be surveyed more intensely but this was not possible due to poor weather. The aggregations seen in this area are likely due to animals clumping at the sea ice edge. It was noted that there are likely bathymetric features that explains why the narwhals are congregating in this area.

The group discussed whether these results could be used to look at the densities that are potentially available to hunters in Disko Bay in the winter for the catch allocation model. However, the allocation model does not calculate the density of whales in the area, and thus would need to be modified to utilise that information.

This abundance estimate was **accepted** by the JWG, but is not utilised in the Catch Allocation model assessment at this time.

Winter estimate from the North Water

NAMMCO/SC/22-JCNB/SWG/2015-JWG/08 includes information on winter abundance in the North Water. The importance of the North Water polynya as an overwintering area for marine mammals has been questioned. One way to address the issue is to assess the abundance of selected marine mammals that are present during winter in the North Water. Visual aerial surveys involving double observer platforms were conducted over the eastern part of the North Water polynya in April 2014. Four species of marine mammals were included in strip census estimation of abundance. Perception bias was addressed using a double-platform survey protocol and a Chapman mark-recapture estimator. Availability bias was addressed by correcting the abundance estimates by the percentage of time animals detected in water were available for detection at the surface. The resulting abundance estimates revealed that 2,085 walrus (95% CI 1,397-3,112), 10,003 bearded seals (6,702-14,932), 2,324 belugas (1,786-2,820) and 3,059 narwhals (1,760-5,316) wintered in the eastern part of the North Water polynya in April 2014. The estimate of the abundance of walrus is larger than previous summer estimates covering the entire North Water and it emphasizes the importance of the habitat along the Greenland coast as a walrus wintering ground. The estimate of belugas is likely negatively biased due to the partial coverage of the potential habitat. The estimate of narwhals is large compared to the few previous observations of narwhals in winter in the North Water and it demonstrates that large numbers of narwhals winter in the North Water. The overall conclusion is that the North Water is indeed an important wintering area for at least walrus, belugas, narwhals and bearded seals.

Discussion by the JWG

These results can be used as information on winter distribution, but not abundance estimates used in the assessment. However, results do provide information suggesting a large number of narwhal use the North Water polynya in late winter and are available to move north, east, and west into summer aggregations areas: Jones Sound-Norwegian Bay, Inglefield Bredning, and Smith Sound. The latter Smith Sound stock included areas along the east coast of Ellesmere Island used by narwhal during the summer aggregation season. Of note, large numbers of narwhal were observed in Makinson Inlet during the Canadian August 2013 survey.

5.4.2 Estimates by management units

New abundance estimates for summering stocks in Canada were presented, but the JWG could not formally review them until full documentation is available. However, the JWG decided to include the Jones Sound-Norwegian Bay and Smith Sound abundance estimates in the Catch Allocation model assessment since there is no other survey information available.

5.4.3 Future survey plans

No new information on survey plans.

5.4.5 Recent changes in distribution in Canada

No new information was available. However, the JWG briefly discussed the Admiralty Inlet and Eclipse Sound abundance estimates from the 2013 Canadian survey as an indication that the two summer stocks may be linked.

5.5 Assessment

5.5.1 Catch Allocation for west Greenland and Canada

Recognizing that the narwhals hunted in different regions cannot easily be attributed to their summering

aggregation based on genetics or other stock identity information, the JWG tasked a sub-group to develop a model that includes the information that is available.

The Catch Allocation sub-group of the NAMMCO-JCNB Joint Scientific Working Group (JWG_{sub}) met 10–12 March 2014 in Copenhagen, Denmark, and again in Ottawa, Canada 9–10 March 2015. The report of these meetings was available as NAMMCO/SC/22-CNB/SWG/2015-JWG/17 (Annex 1).

The Terms of Reference for this meeting were to:

- review information on distribution, movements and harvest locations of narwhal;
- develop an allocation model that will provide a mechanism for assigning harvested animals to all summer stocks based on existing data;
- specify and quantify exchange rates between aggregations and stocks;
- identify and quantify uncertainty in the allocation model and determine implications for management; and
- recommend future work to resolve uncertainties within the model structure.

The main purpose for these meetings was to develop a model for catch allocations for the Baffin Bay narwhal population that is shared by Canada and Greenland, but not to decide on the sustainability and/or provide advice on the actual quotas. The JWG_{sub} reviewed the available data on takes and migratory movements of narwhals and determined that in some areas different stocks of narwhals were available to hunters in different seasons. Data from satellite tags attached to narwhal in summer aggregations and expert opinion was used to determine which summer aggregations were available to hunters in villages and the timing of that availability. Hunts were divided into four seasons to correspond with the spring and fall migrations the summer aggregation period and the overwintering areas. A total of 24 seasonal hunts were identified to be allocated among the 8 summer aggregations. To do this an allocation matrix with 24 rows by 8 columns was devised. The eight columns were the individual summer aggregations of Smith Sound, Jones Sound, Inglefield Bredning, Melville Bay, Somerset Island, Admiralty Inlet, Eclipse Sound, and East Baffin Island. The 24 rows represented 24 hunts in 10 regions and some regions hunts were divided by season. Thus for each summer aggregation and hunt there is a cell in the matrix, and the matrix is devised so that when multiplied by a vector of removals, the resulting vector will determine the total removals from each summer aggregation. The cells in the matrix determined using the tag data or where no tag data was available then expert opinion and the relative abundance of each summer aggregation. The tag data determined the fraction of the summer aggregation that was available to a hunt, which was multiplied by the size of the population to determine the numbers from each summer aggregation exposed to each hunt. These were then divided by the total number of whales exposed to a hunt to determine the proportion of the hunt that came from the summer aggregation. The JWG_{sub} identified a number of points of uncertainty and thus developed a method for testing the sensitivity of the allocation to data uncertainty as well as stochastic variation of the matrix from year to year. See the report from the subgroup for details.

The JWG thanked the JWG_{sub} for their work and recommended that the remaining tasks are now the responsibility of the full JWG. Therefore, the Catch Allocation subgroup work was considered completed.

5.5.2 Assessment of aggregations in West Greenland and Canada (meta population model)

Narwhal Meta Aggregation

NAMMCO/SC/22-JCNB/SWG/2015-JWG/010 combined the catch allocation model for narwhals in East Canada and West Greenland with Bayesian population modelling of the eight summer aggregations of narwhals in the region. The catch allocation model allocates the catches in different hunting areas and seasons to the different summer aggregations, and the population models analyse the impact of these catches on the population dynamics of the eight narwhal aggregations.

The population models run from 1970 (Canadian catches prior to 1977 were assumed to be 0 in the model, see below), and the catch allocation model needs population trajectories from 1970 to the present in order to estimate the catches taken from the different summer aggregations during this period. In an initial run it uses linear transitions between the available abundance estimates; but more elaborate population trajectories are estimated by the fit of the population models to the abundance data. The two models are therefore run in an

iterative manner until the catch histories that are estimated by the allocation model, and the abundance trajectories that are estimated by the population models, converge between runs.

The distributions of takes reflect the uncertainty in the allocation of catches from the hunting areas to the summering grounds, with narrow distributions reflecting little uncertainty, and wider distributions reflecting a more uncertain allocation of the catches.

The population dynamics that are estimated for the different summer aggregations from these catch histories are shown in Figure 1. Some of the summer aggregations, like those in Smith and Jones Sound, have very low catches that hardly affect the dynamics, while the narwhal aggregation in Melville Bay is clearly influenced by the historical takes. The narwhal aggregation around Somerset Island may have an increasing trend, and those in Inglefield Bredning, Admiralty Inlet, Eclipse Sound and East Baffin Island appears relatively stable. The model estimates that nearly all the aggregations are above the maximum sustainable yield level (MSYL) where slightly decreasing trends usually are of no concern. The exceptions are Inglefield Bredning and Melville Bay. Both of these aggregations are estimated to be depleted to levels below the MSYL, implying that future harvest levels should be set to ensure an increasing number of narwhals in these summering areas.

For situations where stocks may be below or above the MSYL realistic management objectives could reflect allowable takes that ensures that stocks below the MSYL are increasing towards the MSYL, while the takes from stocks above the MSYL level should be smaller than the maximum sustainable yield (MSY), e.g., smaller than 90% of the MSY. Given such a management objective, Table 1 shows the estimated annual takes from the different summering aggregations over the next five years that allows this management objective to be fulfilled with a probability from 0.5 to 0.95.

The take of narwhals from the different summering aggregations cannot be managed by consideration of summering grounds exclusively because many narwhals are caught in other hunting areas at other times of the year (e.g., during migration). Instead, management limits for different hunts and season must be considered together. Tables 2 and 3 illustrate two potential scenarios of takes and their relation to management objectives using Table 1. In Table 2, the average catch option (C0) uses the average annual take (including struck and loss) in the different hunts over the five year period from 2009 to 2013 as the takes for the period 2015-2020.

Using the allocation matrix to relate these takes to the removals from summer aggregations yields values for C0 in Table 3. The values for C0 are then compared to the risk levels in Table 1 to estimate the probability of meeting management objectives. In this example, setting harvest at the average for the years 2009-2013 of possible distribution of hunt allocations using probabilities of management success of 70% for summer aggregations in Greenland and 80% for summer aggregations in Canada (C0) we find that the harvest from Melville Bay stock (Upernavik in summer) and East Baffin stocks do not meet the management objectives. Making ad hoc adjustments, the required catch reductions in Greenland (30 in Upernavik, summer) and Canada (1 in summer and 1 in fall in Baffin Island South; 1 in spring, 9 in summer and 4 in fall in Baffin Island Central) are then moved to the hunts in each country that are taken from the summer aggregations that are least susceptible to overharvest (i.e., Uummannaq and Central Canadian Arctic). Scaling is then applied to all the hunts in both countries that remain below the accepted risk to develop an example (C1, Table 2) of possible distribution of hunt allocations that meet the probabilities of management success for the summer aggregations (C1, Table 3). Note that Melville Bay does not meet the objective in this example but is substantially closer than the C0 example.

While this example (C1) does meet most of the management objectives, we reiterate that it is one possible allocation, but other allocation scenarios may also meet the example management objectives as determined by the Commissioners.

Robustness trials (NAMMCO/SC/22-JCNB/SWG/2015-JWG/010d,e) were conducted in which the Z value which determine level of variation in the allocation matrix (high values >1000 having no variation and low values <10 having very high variation) was set at 100 and all takes were multiplied by 1.2 respectively. The new Canadian abundance estimates were included in these runs. The JWG concluded that the results indicated that the models were robust to changing Z values and uncertainty in catches. NAMMCO/SC/22-JCNB/SWG/2015-JWG/010a,b,c represent earlier iterations of the analysis (See Appendix 3 for more information).

Advice by the JWG

While the model can be used to determine the risk of a particular harvest regime, the JWG **seeks further guidance** from the JCNB/NAMMCO on the management objectives.

The catch allocation algorithm in paper NAMMCO/SC/22-JCNB/SWG/2015-JWG/010 uses agreed upon abundance estimates, plus the abundance estimates from Smith Sound and Jones Sound from the 2013 survey in Canada. The JWG acknowledges that the Smith Sound and Jones Sound estimates have not been formally reviewed by the JWG but were necessary for the analysis as they are the only surveys available in these areas, but the impact of including these is considered minimal given the low expected catches coming from Canada and Greenland hunts of these stocks.

In Table 2 above, the average removals from 2009-2013 (C0) from Melville Bay did not meet the above management objective example of 70% probability of success and East Baffin did not meet 80%, thus we recommend reducing the hunts that remove narwhals from these stocks. The JWG proposed an alternative using a simple approach to reallocation described above as an example of adjusting take limits to meet the management objectives. The JWG **recommends** using the catch allocation model with the assessment models to verify that allowable takes do not exceed acceptable risk levels.

Table 1. Catch objective trade-off per stock. The total annual removals per stock that meet given probabilities (P) of meeting management objectives. The simulated period is from 2015 to 2020, and this assumes a 50% catch of females.

P	Smith Sound	Jones Sound	Inglefield Bredning	Melville Bay	Somerset Island	Admiralty Inlet	Eclipse Sound	East Baffin Island
0.5	284	231	147	108	914	394	398	192
0.55	259	215	135	102	871	371	377	180
0.6	231	200	123	97	828	347	354	169
0.65	206	186	111	90	780	325	332	158
0.7	185	171	98	82	732	301	310	147
0.75	165	156	83	72	684	273	287	135
0.8	144	141	68	63	635	243	262	123
0.85	123	126	52	53	580	213	234	110
0.9	100	106	33	40	512	177	198	94
0.95	67	78	5	21	403	124	151	72

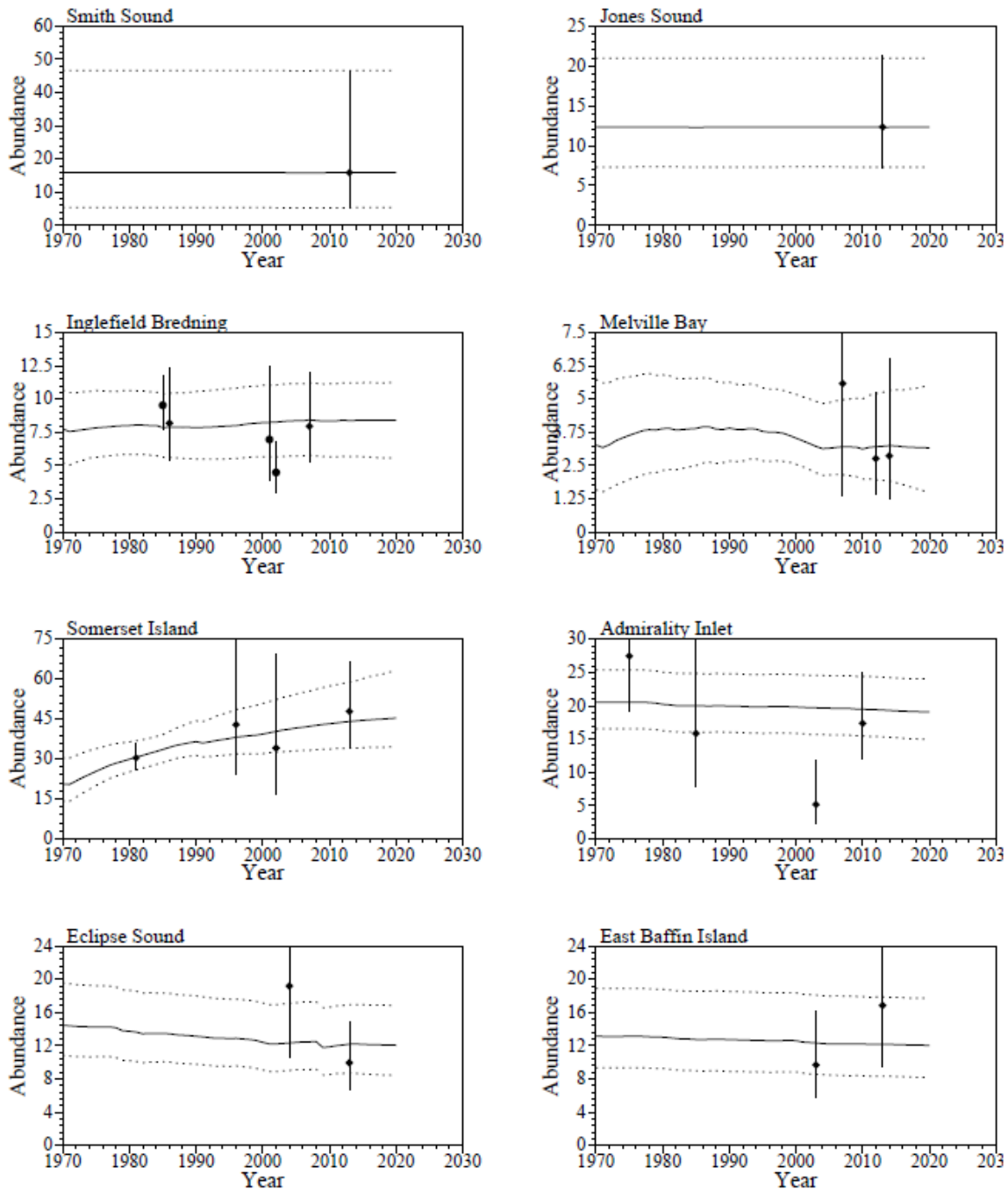


Fig 1. The population trajectories from the assessment model by summering aggregation. The medians (black) and 90% confidence intervals (dotted) of the estimated population dynamics from the eight summer aggregations of narwhals in East Canada and West Greenland, together with abundance estimates from aerial surveys (dots).

Table 2. Two potential scenarios of takes of narwhal in the 24 different hunts.

Hunt	Season	Catch Options	
		C0 (Average)	C1
Etah	Spring	4	5
Qaanaaq	Summer	98	98
Grise Fiord	Spring	7	9
Grise Fiord	Summer	11	15
Grise Fiord	Fall	0	0
Upernavik	Summer	100	70
Ummannaq	Fall	86	154
Disko Bay	Winter	73	97
Central Canadian Arctic	Spring	4	6
Central Canadian Arctic	Summer	74	118
Central Canadian Arctic	Fall	2	3
Arctic Bay	Spring	31	41
Arctic Bay	Summer	141	188
Arctic Bay	Fall	0	0
Pond Inlet	Spring	58	77
Pond Inlet	Summer	55	73
Pond Inlet	Fall	4	5
Baffin Island Central	Spring	12	11
Baffin Island Central	Summer	100	91
Baffin Island Central	Fall	44	40
Baffin Island South	Spring	5	5
Baffin Island South	Summer	9	8
Baffin Island South	Fall	12	11
Baffin Island South	Winter	0	0

Table 3. Examples of future annual removals (C#) per summer aggregation, with associated probabilities (P#) of fulfilling management objectives. The different removals follow from the catch options in Table 2, and the 90% confidence intervals of the estimates are given by the sub and super scripts.

	Smith Sound	Jones Sound	Inglefield Bredning	Melville Bay	Somerset Island	Admiralty Inlet	Eclipse Sound	Baffin Island
C0	4	18	98	141	265	226	207	152
	4	18	98	101	175	161	104	120
P0	1.00	1.00	0.7	0.56	0.99	0.92	0.98	0.81
	1.00	1.00	0.7	0.26	0.99	0.83	0.89	0.68
C1	5	24	98	126	399	296	262	138
	5	24	98	72	283	212	134	110
P1	1.00	1.00	0.7	0.75	0.98	0.85	0.96	0.85
	1.00	1.00	0.7	0.36	0.95	0.71	0.8	0.74

5.5.4 East Greenland

Assessment of East Greenland

NAMMCO/SC/22-JCNB/SWG/2015-JWG/16 provided separate assessments for narwhals at the two hunting areas in East Greenland, i.e., in the Ittoqqortormiit and Tasilaq/Kangerlussuaq areas. Population models with exponential growth were fitted to a single abundance estimate from 2008 for each area and an age-distribution sampled from animals caught around Ittoqqortormiit between 2007 and 2010. Assuming an average natural adult survival of either 0.97 or 0.98 in the prior, it was estimated that narwhals in the Ittoqqortormiit area have increased slightly, while narwhals in the Tasilaq/Kangerlussuaq area might be stable or increasing slightly. The current growth rate in the absence of harvest was estimated to lie between 1.2% (90% CI:0-3.6) and 3.7% (90% CI:1.6-5.9), depending upon model and area.

Table 4. Narwhal in East Greenland. The estimated trade-off between the total annual removal and the probability (P) of an increasing stock from 2015 to 2020, for Ittoqqortormiit and Tasiilaq in East Greenland.

P	0.70	0.75	0.80	0.85	0.90	0.95
Ittoqqortormiit	50	40	30	20	10	4
Tasilaq	16	13	9	4	1	0

Discussion by the JWG

The JWG noted that the only new information available was updated harvest numbers.

The updated assessment suggests somewhat lower catch than the previous advice for the Ittoqqortormiit area. The JWG **recommends** this lower quota (Table 4 above) since we are further away in time from the data that is available. The JWG also **recommends** that a new survey be conducted in East Greenland.

The JWG discussed whether the East Greenland stocks should be considered depleted, stable or growing, information that would assist in setting management objectives.

5.6 Future research requirements

The JWG recommends that future research includes:

- 8) Aerial survey in East Greenland
- 9) More satellite tag and dive data from the stocks in West Greenland and Eastern Canada to obtain more information about movement between summer aggregations and information for availability bias for survey correction factors
- 10) Developing the Hidden Markov model to incorporate perception bias, which requires detailed dive cycle information

6. BELUGA

6.1 Stock structure

No new information was available.

6.2 Biological parameters

No new information was available.

6.2.1 Age estimation

Ageing using aspartic acid racemisation

Ferguson presented information on using aspartic acid racemisation as a technique for ageing. Age determination is key to studying population dynamics and life-history, which are the basis for wildlife management. Mammal ages have been estimated using different methods and for beluga whales the traditional method is counting tooth growth layer groups (GLG). To explore and test novel methods of ageing requires testing validity against the traditional tooth GLG method. Aspartic acid (AA) is a non-essential α -amino acid that is used as a building block for proteins. AA is optically active with two isomeric forms, D- and L-. In living organisms, only the L-isomer is synthesized and useful for biological purposes, and organisms maintain

the disequilibrium state metabolically. In the absence of such a maintenance, a process called racemization results in the L-isomer being converted to the D-isomer. At birth, the theoretical ratio of D/L should be ∞ , although the true value is usually a number slightly greater than zero. Therefore, the extent to which racemization has occurred in an animal can be used as a measure of age. We explored the AA racemization technique for ageing beluga whales using mass spectrometry (MS) detection of D/L ratio of beluga eye lenses collected from subsistence hunts. Preliminary results appear promising as the D/L ratio compared to GLG age in 25 beluga resulted in a significant relationship ($y = 0.00338x + 0.0130$; $r^2 = 0.932$). We plan to further develop the method for beluga ageing as a replacement to GLG ageing of beluga whales.

Discussion by the JWG

The group noted that this is an interesting technique, but that it should include young animals, if possible. Ferguson informed the group that they are requesting more samples, including those from young animals but that sampling from the hunt implies that the sample will be biased toward older animals.

Using fatty acids for ageing

Marcoux et al. (in press, Marine Mammal Science) was presented. Recently, a few studies have highlighted the potential of using fatty acid (FA) composition in blubber biopsy samples to estimate age in some cetaceans. We explore the opportunity of using this technique to estimate the age of free-ranging belugas from three different populations. Belugas were sampled post-mortem for blubber FA analysis and aged by counting the number of growth layer groups in teeth dentine. We found significant positive and negative relationships between some FAs and age. These relationships were stronger with outer blubber layer samples, the layer which is the most accessible via biopsy, than in inner or middle layer samples, a pattern that is consistent with observed turnover rates and biological function across the blubber depth. The FA 12:0, 14:1n-7 and 14:1n-9 were promising correlates of age in belugas, allowing estimation of age with a precision of ± 7 -10 years. Further work is required to determine the mechanisms underlying changes in FA composition with age and whether these mechanisms are stable through time and across populations. Future effort should concentrate on short-chain fatty acids.

Discussion by the JWG

The JWG noted that the negative correlations with age are interesting, but the mechanisms determining the correlations are not well understood. Most of the negatively correlating FAs are dietary FAs, but some are biosynthesized. Ideally, biosynthesized FA would be used instead of dietary FA since differences in dietary FAs could also be due to differences between populations, life history, etc. Interestingly, some of the FA found to be correlated with age in belugas are also some of the same FA found to be correlated with age in killer whales.

6.2.2 Reproductive rates

Weaning ages estimated by stable isotopes

Ferguson presented information on determining weaning ages based on using stable isotopes in teeth. Beluga whales have a protracted nursing period estimated to last from 6-32 months, although current estimates of beluga nursing duration are derived using approaches subject to capture bias. Recent studies have shown stable isotope (SI) profiles of dentine growth layer groups (GLGs) in marine mammal teeth serve as a reliable nursing proxy, and can be used to assess individual weaning patterns. We measured stable isotope ratios of nitrogen ($\delta^{15}\text{N}$) and carbon ($\delta^{13}\text{C}$) of dentine GLGs in teeth from eastern Canadian Arctic belugas to estimate weaning age and assess relative contributions of milk and solid food during the nursing period. $\delta^{15}\text{N}$ declines of $\sim 1\%$ over the 1st three GLGs of most individuals were interpreted as evidence of weaning. Individual $\delta^{15}\text{N}$ profiles indicated 15 of 27 whales were completely weaned by the end of their 2nd year, although a number of whales were weaned by the end of their 1st or 3rd year (9 and 3, respectively). Intermediate GLG2 $\delta^{15}\text{N}$ values relative to GLGs 1 and 3 indicated most whales consumed a mixture of milk and solid food during their 2nd year, consistent with gradual weaning. Contrary to predictions based on parental care theory, nursing duration was not related to relative GLG width (used as a proxy for somatic growth). Also, no differences were found between females and males, or among populations. $\delta^{13}\text{C}$ variation was not a reliable indicator of nursing duration, as approximately half of the whales showed no ontogenetic $\delta^{13}\text{C}$ patterns across GLGs deposited over the nursing period. This study provided novel life history information which may inform beluga conservation and management decisions, and indicates belugas share prolonged nursing duration marked by individual variation observed in other odontocetes.

Discussion by the JWG

The group discussed that it is important to know how long the SI signature remains in the tissues. Nitrogen intake and body mass would need to be considered to estimate turnover.

The group noted that identifying a specific weaning age may not be possible using annual results in changes in stable isotopes.

The group also noted that there was more individual variation than previously expected.

6.3 Recent catch statistics

Catch statistics for Greenland

Paper NAMMCO/SC/22-JCNB/SWG/2015-JWG/05 included information and statistics including trade statistics on catches of white whales, or belugas, in West Greenland since 1862. The period before 1952 was dominated by large catches south of 66°N that peaked with 1,380 reported kills in 1922. Catch levels in the past five decades are evaluated on the basis of official catch statistics, trade in *mattak* (whale skin), sampling of jaws and reports from local residents and other observers. Options are given for corrections of catch statistics based upon auxiliary statistics on trade of *mattak*, catches in previous decades for areas without reporting and on likely levels of loss rates in different hunting operations. The fractions of the reported catches that are caused by ice entrapments of whales are estimated. During 1954-1999 total reported catches ranged from 216 to 1,874 and they peaked around 1970. Correcting for underreporting and killed-but-lost whales increases the catch reports by 42% on average for 1954-1998. If the whales killed in ice entrapments are removed then the corrected catch estimate is on average 28% larger than the reported catches. Catches declined during 1979-2014 to levels below 300 whales per year after 2004. All catches are assumed to be taken from the Somerset Island summering stock of belugas and all the catches in West Greenland are presumably taken from the fraction of that stock that winters in West Greenland. The exception is the winter catches in Qaanaaq (approx. 5% of annual catches in Qaanaaq) that likely are taken from the fraction that winter in the North Water. It is unknown which stock is supplying the summer hunt in Qaanaaq (approx. 15% of annual catches in Qaanaaq). A few confirmed catches (and sightings) of belugas have been recently been report from East Greenland.

Discussion by the JWG

The JWG noted that these catch statistics did not include any new methods in analysis or struck and lost rates, and therefore the method has already been approved. The medium and high options are provided for the assessment model as correction options.

The group noted that in 2013 there were higher catches than usual in Upernavik. The reason for this is not known, however it may be informative to look at what the seismic activities were in 2013. It is possible that seismic activities could have driven the whales closer to shore, making them more susceptible to hunting. It is already known that belugas are easily scared into the coast, and also that the migration patterns of belugas are potentially affected by seismic activities. Further discussion of the possible effects of disturbance are addressed in Item 10.

Under-reporting remains a potential problem however there is little means to correct for this.

Catch statistics from Canada

Ferguson presented NAMMCO/SC/22-JCNB/SWG/2015-JWG/12 that includes the catch statistics from Canada. The summary of the document is under Item 5.3.1 in the narwhal section.

Discussion by the JWG

It is not thought that the catches from Iqaluit and Pangnirtung are from a shared stock with Greenland.

The JWG agreed that there is a need to construct a table that better illustrates which catches are thought to be shared. This table needs to go back to 1970 to be included in the assessment models.

The catches presented here do not include struck and lost rates. Struck and lost data has been collected but has not been analysed.

6.4 Abundance

6.4.1 Recent and future estimates

Abundance of belugas in West Greenland

Heide-Jørgensen presented paper NAMMCO/SC/22-JCNB/SWG/2015-JWG/11. An aerial visual survey of the density and abundance of belugas was conducted in the eastern part of Davis Strait and Baffin Bay in March-April 2012. The survey was conducted as a double platform aerial line transect survey, and sampled approximately 7,800 km of the total survey area of ca. 243,000 km². The largest abundance of whales was found at the northern part of Store Hellefiske Bank, at the eastern edge of the Baffin Bay pack ice, a pattern similar to that found in nine systematic surveys conducted since 1981. A clear relationship between decreasing sea-ice cover and increasing offshore distance of beluga sightings was established from all previous surveys, suggesting that belugas expand their distribution westward as new open water areas on the banks of West Greenland open up earlier in spring with reduced sea-ice coverage or early annual ice recession. No dive data specific to belugas in West Greenland in winter are available and availability correction factors for whales that are submerged during the passing of the plane must be developed from time-at-depth series from other areas and seasons. Methods that take account of stochastic animal availability by using independent estimates of the availability process and forward as well as perpendicular distances of sightings, were used to estimate beluga abundance. Abundance estimates from two of the three best models fitted to the data were found to be sensitive to a single large school (3 times larger than any other) that was detected in the stratum with the highest abundance. The only one of these three models that appears robust to this large school size variation was preferred. It yields an estimate of 7,456 beluga whales (CV=44%, 95% CI 3,293; 16,987). Belugas are within detectable forward distance for 3.3% of their mean dive cycle length and hence the survey is a nearly instantaneous process. A conventional distance sampling estimator of individual abundance using the same data, and “correcting” availability bias by dividing the estimate by the proportion of time belugas are estimated to be available (43%) yielded an estimate of 7,546 whales (CV=38%, 95% CI 3,462; 16,450). A mark-recapture distance analysis correcting for perception bias, and using the same availability factor of 43%, estimates the abundance to be 9,072 whales (CV=32%, 95% CI 4,895; 16,815).

Discussion by the JWG

The group noted that they appreciate the different approaches that were presented.

The population remains depleted versus historical levels (20,000 in ca 1980, probably previously even higher than that), but has levelled off after a catch quota was introduced (and thus catches reduced).

The JWG agreed to accept the mark-recapture abundance estimate (9,072 CV=0.32, CI: 4,895-16,450). The paper makes the case that it is almost instantaneous, and the bias introduced from not being completely instantaneous is almost the same as when the Hidden Markov model is used (which tries to remove any bias from not being instantaneous). The survey was almost instantaneous because the observers were surveying on the side of ice floes, and observers would not be able to detect anything further away anyway. The ice floes provided spatial cues so it is likely that the observers looked straight down.

Winter Abundance in the North Water

The summary of paper NAMMCO/SC/22-JCNB/SWG/2015-JWG/08 is given under Item 5.4.1 in the narwhal section.

Discussion by the JWG

This abundance estimate is likely an underestimate due to the strip width and the fact that the entire area was not surveyed, making this a conservative approach.

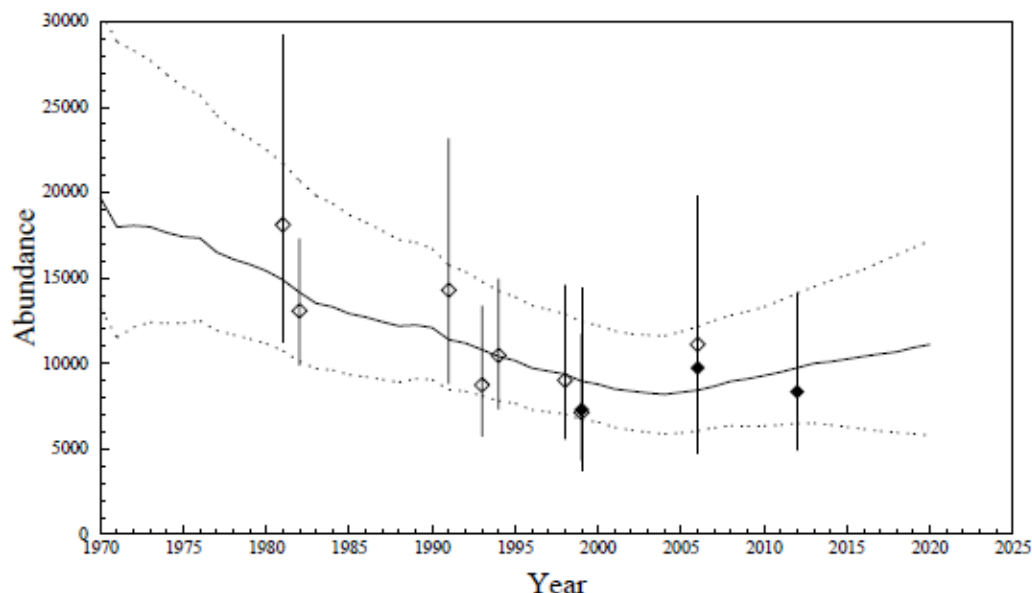
6.5 Assessment update

6.5.1 West Greenland

NAMMCO/SC/22-JCNB/SWG/2015-JWG/09 used recent abundance estimates and historical catches in an age-structured population model with density-regulated growth to perform Bayesian assessments of the beluga aggregation that winters off West Greenland. The model starts from a stable age-structure in 1970 under the assumption that the 1970-abundance was below the current carrying capacity, and it was applied with a high and low prior on adult survival.

The dynamics of the high survival model is shown in Figure 2. It estimates a decline from 19,140 (90% CI:12,680-28,260) individuals in 1970 to a maximal depletion of 8,130 (90% CI:5,740-11,440) in 2004, and an increase to 11,420 (90% CI:6,370-17,850) individuals in 2020 (assuming yearly post 2014 catches of 294). The predicted change from a declining to an increasing population was caused by the introduction of quotas in Greenland, with annual catches in the order of 500 to 700 reduced to less than 200 after 2004. Given total annual removals of 320 individuals from 2015 to 2020, the low survival model estimates that there will be a 70% chance of an increasing population over the period.

Figure 2. The estimated dynamics (curves) of the aggregation of belugas that winter off West



Greenland, together with the abundance estimates from aerial surveys (absolute estimates solid diamonds; relative estimates open diamonds). The bars and dotted curves show the 90% confidence interval.

Discussion by the JWG

This method has been largely reviewed before by the JWG. The only major difference from previous is the initiation of stable age structure, due to separation from catch history.

The model was reanalysed using a beta distribution for the birth rate using data from Greenland (11/36 mature females pregnant; Heide-Jørgensen and Teilmann 1993).

The group discussed the age at maturity that is used in the model, and whether to use an age at maturity based on data that is available rather than a uniform prior. The age at maturity data available suggests that maturity is reached between 8 and 14 years (based on a low sample size of females in the hunt). The JWG agreed to continue using the age at maturity of 8-12 that is currently in the model.

Advice from the JWG

Reiteration of Past Advice

The JWG **reiterates** the previous advice from 2005 and 2012 about seasonal closures. The following seasonal closures are **recommended**:

- Northern (Uummanaq, Upernavik and Qaanaaq): June through August
- Central (Disko Bay): June through October
- Southern (South of Kangaatsiaq): May through October.
- For the area south of 65°N, it is recommended that no harvesting of beluga be allowed at any time.

The function of these closures is to protect the few animals that may remain from historical summer aggregations in Greenland, and to allow for the possibility of reestablishment of the aggregations.

No specific advice was given on the North Water, noting that the removals remain at a low level relative to the population size derived from the 2009-2010 and 2014 surveys in the North Water and around Somerset Island in 1996, and assuming that future catches remain at low levels.

New Advice

With the new accepted abundance estimate for belugas in West Greenland in 2012, the JWG provided updated advice in Table 5 below.

Table 5. Beluga in West Greenland. The estimated trade-off between the total annual removal and the probability (P) of an increase in the number of beluga that winters off West Greenland over the period from 2015 to 2020.

P	0.70	0.75	0.80	0.85	0.90	0.95
West Greenland	320	290	260	225	195	145

7. TRADITIONAL KNOWLEDGE

Traditional knowledge was used when available and relevant.

The JWG was informed that DFO in collaboration with other groups (e.g., Government of Nunavut and World Wildlife Fund) has been collecting traditional knowledge on narwhals. The Government of Nunavut through a Coastal Inventory Survey is also collecting information on distribution in belugas and narwhals, and more information may be provided at the next JWG meeting if available.

8. IMPACT OF HUMAN-MADE-NOISE

In Greenland, 2010-12 were the highest years of seismic exploration. In 2012, narwhals were observed during the survey to be closer to shore compared to the previous survey, potentially changing availability to hunters. There was little seismic exploration in 2013, and none in 2014. In 2015, there is planned seismic exploration in East Greenland. Ice entrapments have been reported in areas where animals are not usually located, and it is speculated that displacement resulting from anthropogenic noise could be the cause. It is possible that the whales could be remaining on, or moving back to, their summering grounds due to noise on their migration pattern.

While mechanisms by which stressors can cause harm are relatively straightforward, level and context of exposure leading to biological meaningful harassment, or to effects on short- and long-term health are more difficult to assess. In the case of sub-lethal effects related to disturbance, the conceptual PCoD framework, i.e., the Population Consequences of Disturbance (e.g., Harwood et al. 2013), sets the main mechanisms by which disturbance may lead to effects on health or vital rates, and ultimately on population dynamics (NRC 2005). Effects can occur as a result of acute or chronic exposure to stressors, which may lead to detrimental physiological changes, and ultimately to effects on health and vital rates, but without necessarily eliciting observable behavioural reactions (Gills et al. 2001; Southall et al. 2007; Ellison et al. 2012; Wright et al. 2007). These subtle mechanisms may be particularly important in the case of chronic stressors, such as elevated ambient noise, regular vessel-interactions, or environmental contamination (e.g., Wright et al. 2007; Rolland et al. 2012; Tanabe 2002; Ross 2006; Breuner et al. 2013), or when operations overlap with key habitat with little alternative options, or with critical periods.

A Symposium on the impacts of human disturbance on arctic marine mammals planned for fall 2015, convened by NAMMCO. A summary report from this Symposium will likely be available at the next JWG meeting.

Baffin Island

Some Inuit and other groups have expressed concerns over the National Energy Board's (NEB) approval of the "2011 Northeastern Canada 2D Marine Seismic Survey" proposed for Baffin Bay and Davis Strait, off the coast of Baffin Island, Nunavut, by TGS/PGS/MKI (the consortium of companies who submitted the proposal to NEB) proposed to be conducted July 2015-November 30, 2019.

10. OTHER BUSINESS

10.1 NAMMCO question regarding Ageing workshop

10.1.1 Narwhal

10.1.2 Beluga

As of last JWG meeting, the Ageing workshop had been conducted, and the results are still in being analysed. *The NAMMCO Scientific Publications Volume 10: Age estimation of marine mammals with a focus on monodontids* is underway, with 8 papers published as online early versions, and additional papers are nearing completion.

10.2 Assessments in data-poor situations

At the next JWG meeting, the groups should discuss guidelines for giving advice in data-poor situations.

10.3 Review of ROP

The group reviewed the draft ROP and made a few minor changes (Appendix 4). The JWG **agreed** to adopt these ROP, send the document to JCNB and NAMMCO for approval.

11. ADOPTION OF REPORT

The report was adopted at 17:02 on the final day. The group thanked the Chair for his leadership.

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Appendix 1 - LIST OF PARTICIPANTS

Joint Meeting of the

**NAMMCO SCIENTIFIC COMMITTEE WORKING GROUP ON THE POPULATION STATUS OF
NARWHAL AND BELUGA IN THE NORTH ATLANTIC**

And the

**CANADA/GREENLAND JOINT COMMISSION ON CONSERVATION AND MANAGEMENT OF
NARWHAL AND BELUGA SCIENTIFIC WORKING GROUP**

Ottawa, Canada, 11-13 March 2015

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Appendix 2 - List of Documents

Document No.	Document Title
NAMMCO/SC/22-JCNB/SWG/2015-JWG/01	List of participants
NAMMCO/SC/22-JCNB/SWG/2015-JWG/02	Draft agenda
NAMMCO/SC/22-JCNB/SWG/2015-JWG/03	Draft list of documents
NAMMCO/SC/22-JCNB/SWG/2014-JWG/04	Draft Rules of Procedure
NAMMCO/SC/22-JCNB/SWG/2015-JWG/05	Heide-Jørgensen, MP and Hansen RG. Catch statistics for belugas in Greenland 1862 to 2014.
NAMMCO/SC/22-JCNB/SWG/2015-JWG/06	Heide-Jørgensen, MP and Hansen RG. Reconstructing catch statistics for narwhals in Greenland 1862 to 2014
NAMMCO/SC/22-JCNB/SWG/2015-JWG/07	Watt et al. Narwhal dive behaviour
NAMMCO/SC/22-JCNB/SWG/2015-JWG/08	Heide-Jørgensen et al. Winter abundance of large marine mammals in the North Water
NAMMCO/SC/22-JCNB/SWG/2015-JWG/09	Witting and Heide-Jørgensen. Population model for West Greenland beluga.
NAMMCO/SC/22-JCNB/SWG/2015-JWG/010	Witting L. Meta population modelling of narwhals in East Canada and West Greenland.
NAMMCO/SC/22-JCNB/SWG/2015-JWG/11	Heide-Jørgensen et al. Abundance of belugas in West Greenland 2012.
NAMMCO/SC/22-JCNB/SWG/2015-JWG/12	Hall et al. Catch Statistics for Narwhal and Beluga in Selected Communities in Nunavut, Canada (2004-2013)
NAMMCO/SC/22-JCNB/SWG/2015-JWG/13	Canada Resource Managers Questions to JCNB
NAMMCO/SC/22-JCNB/SWG/2015-JWG/14	Hansen et al. Abundance of narwhals in Melville Bay
NAMMCO/SC/22-JCNB/SWG/2015-JWG/15	Hansen et al. narwhals in E Baffin Bay
NAMMCO/SC/22-JCNB/SWG/2015-JWG/16	Witting and Heide-Jørgensen EG narwhals
NAMMCO/SC/22-JCNB/SWG/2015-JWG/17	Narwhal Catch Allocation Subgroup Report

For Information Documents

Document No.	Document Title
NAMMCO/SC/22-JCNB/SWG/2015-JWG/O/01	Watt et al. (2013) How adaptable are narwhal? A comparison of foraging patterns among the world's three narwhal populations
NAMMCO/SC/22-JCNB/SWG/2015-JWG/O/02	Instantaneous availability bias correction for calculating aerial survey abundance estimates for narwhal (<i>Monodon monoceros</i>) in the Canadian High Arctic
NAMMCO/SC/22-JCNB/SWG/2015-JWG/O/03	Watt and Ferguson (2015) Fatty acids and stable isotopes ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) reveal temporal changes in narwhal (<i>Monodon monoceros</i>) diet linked to migration patterns
NAMMCO/SC/22-JCNB/SWG/2015-JWG/O/04	SC19-14-JWG_2012 Final Report (<i>report from last JWG meeting</i>)
NAMMCO/SC/22-JCNB/SWG/2015-JWG/O/05	Catch Allocation PRELIMINARY Report REVISED July 2014 (<i>report will be updated after Catch Alloc. meeting in Ottawa 9-10 March</i>)
NAMMCO/SC/22-JCNB/SWG/2015-JWG/O/06	Kelly et al. (2014) Mating ecology of beluga (<i>Delphinapterus leucas</i>) and narwhal (<i>Monodon monoceros</i>) as estimated by reproductive tract metrics
NAMMCO/SC/22-JCNB/SWG/2015-JWG/O/07	Marcoux et al. (in review) Age estimation of belugas <i>Delphinapterus leucas</i> using fatty acid composition: a promising method

Appendix 3 - Information on the different versions of the JWG 2015 10 paper

The complete paper is referred to as JWG10. The following versions are referred to in more specific cases. All versions are available from the NAMMCO Secretariat.

- JWG10a: File: JWG_2015_10_2014_Matrix: Based on the availability matrix from the last meeting of the allocation group
- JWG10b: File: JWG_2015_10_Uniform_B: As JWG_2015_10_2014_Matrix but with new availability matrix
- JWG10c: File: JWG_2015_10_Beta_B: As JWG_2015_10_Uniform_B but with informative Beta priors on the reproductive rate
- JWG10d: File: JWG_2015_10_n100: As JWG_2015_10_Beta_B but with soft soft zeros and soft soft ones ($z=100$)
- JWG10e: File: JWG_2015_10_C1.2: As JWG_2015_10_Beta_B but with all catches multiplied by 1.2
- JWG10f: File: JWG_2015_10_Advice: As JWG_2015_10_Beta_B but with some of the 2013 abundance estimates from Canada removed

Appendix 4

*The following edits were made to the draft Rules of Procedure, and were adopted by the JWG at the March 2015 meeting in Ottawa. Deletions are marked by ~~strikethrough~~ and new text is in **bold**.*

Rules of Procedure for the Scientific Joint Working Group (JWG) of the North Atlantic Marine Mammal Commission (NAMMCO) and the Joint Canada Greenland Commission on Narwhal and Beluga (JCNB)

I. Terms of Reference

1. The JWG shall provide scientific advice to the Councils of NAMMCO and the JCNB on such matters that are referred to it, and ensure that this advice is based on the best available scientific findings at any given time. This includes review and evaluation of data on stock identity, biological parameters, stock size, catch history and other information necessary for conducting an assessment of the species or stock in question and for providing advice on catch limits and conservation.
2. The JWG may make proposals to NAMMCO and the JCNB concerning any scientific tasks to be included in its future work.

II. Membership

1. Each Party (¹¹Member Country/¹²Organisation) shall nominate scientists and other specialists as members of the JWG. These members may serve until otherwise notified, and may vote on scientific matters where a decision is required. However, when procedural or organisational matters are being dealt with, each Party shall have one vote.
2. The JWG shall be jointly chaired by two Chairs: one representing the interests of the JCNB and the other of NAMMCO. These chairs shall be appointed by the two organisations respectively, and they may serve for ~~three years~~ **two meetings**, after which they may be re-elected **appointed**.
3. If for any reason a Chair is unable to complete his/her term of office, a new Chair shall be ~~elected at a regular meeting. If needed, a postal election of the Chair can be held.~~ **appointed by JCNB or NAMMCO.**
4. ~~The JWG may, Each party~~ on an ad-hoc basis and subject to approval of the Councils of both NAMMCO and the JCNB **may** nominate other experts to participate in meetings of the Committee as *ex officio* non-voting members. Any such nomination of experts must reach the **relevant party** (Secretary of NAMMCO ~~and or~~ the JCNB Commissioners) no later than 30 days before the start of the meeting in question. **Requests within 30 days of the meeting will be forwarded to the NAMMCO and JCNB Councils at the discretion of the co-Chairs.**

III. Observers

1. Attendance of observers shall not be permitted at the meetings of the JWG unless otherwise decided by the Chairs after consultation with members of the JWG and ~~approved by~~ **notification to** the Councils of NAMMCO and the JCNB Commissioners. Observers may not vote, but may contribute to the meeting if so

¹¹ Canada and Greenland

¹² NAMMCO

allowed by the Chairs. Observers must regard all matters discussed as confidential until the final approved reports from the JWG meetings are publicly available.

IV. Organisation

1. The JWG is responsible for collecting and compiling the necessary information for providing scientific advice. While avoiding duplication of work being carried out elsewhere, the JWG decides where and how this information is to be obtained. If the JWG considers it necessary to consult information not available in the published literature or in the possession of any of the Members, any cooperation in this field with external authorities shall be undertaken by the JWG Chairs in consultation with NAMMCO and the JCNB Commissioners.
2. The JWG may establish designated Working Groups and Workshops on clearly defined subjects related to the work needed to be carried out for dissemination of the required scientific advice.
4. The Working Groups and Workshops report their findings in writing to the JWG according to their terms of reference.
5. The JWG reports its findings in writing to the ~~Councils~~ **Scientific Committee** of NAMMCO and the JCNB within ~~four~~ **eight** weeks after the conclusion of its deliberations. The contents of the report shall be considered strictly confidential ~~prior to that~~ **until released by either NAMMCO or JCNB**. The Chairs seek to have all views expressed on substantive matters during the deliberations of the JWG made clear in its report and the wording approved by the members before the end of its meeting ~~or~~. **Minor edits may be approved** by correspondence. Approval of the report requires consensus among the members.

V. Meetings

1. The JWG shall meet as required in order to provide updates on scientific advice to NAMMCO and the JCNB for management.
2. A provisional agenda for ~~all~~ JWG meetings shall be developed by the Chairs and distributed to the members no later than 30 days prior to the meeting in question. Comments or suggestions for revision of the provisional agenda ~~shall~~ **should** reach the Chairs no less than 10 days prior to that meeting.
3. The Chairs ~~shall~~, in consultation with ~~other~~ members of the JWG **should** ensure that key ~~documentation of relevance to the provisional agenda is~~ **documents are** available at the ~~start of each meeting~~. **In addition, where necessary, Chairs can request NAMMCO or the JCNB to provide information necessary for decisions.** This may involve compilation of published information and invitation to members, Parties, Working Group Chairs or external experts to submit and present scientific papers at the meetings. Any scientist may submit scientific paper(s) for consideration by the JWG, as appropriate.
4. Each Party having information on the biology of marine mammals relevant for management objectives, including research and statistical material on catches of relevant species or stocks, shall briefly report on such information at the relevant meetings of the JWG.
5. The JWG may make proposals for Contract Studies to be conducted on specific agenda items to be dealt with at its meetings. These will be coordinated by the Secretariat of NAMMCO in correspondence with the JCNB Commissioners.
6. The Secretary of NAMMCO, in correspondence with the JCNB Commissioners, may, with the concurrence of the Committee, set technical guidelines for the preparation, format and presentation of all meeting documents, including type and format of data on catches that each Party reports with respect to any relevant catch operation.

Report of the Joint meeting of NAMMCO/JCNB

7. ~~Titles of Meeting~~ documents outlined in V.3.-5. above shall, ~~if possible,~~ reach the Secretariat of NAMMCO no less than 10 days in advance of the meeting in question and be distributed ~~prior to the meeting to the members of the JWG after consultation with the Chairs.~~ **within 7 days** of the **meeting**. ~~A copy of the correspondence should be given to JCNB Commissioners in Greenland and Canada/Nunavut.~~ All documents registered before the end of the first day of **available 7 days prior** to the meeting shall be considered Primary Documents for consideration at the meeting. **Later documents can be included at the discretion of the Chairs.**

8. English shall be the official language of the JWG and all primary documents shall be written in English. The Chairs can give exemptions from this general rule after consultation with other members and the Secretary of NAMMCO and JCNB Commissioners.

VI. Data Availability

1. The reports of the JWG and any subsidiary Working Groups and Workshops, and other scientific papers presented to the JWG shall be made available by the NAMMCO Secretariat, in correspondence with JCNB Commissioners to anyone whom so wishes, subject to approval by the Councils of NAMMCO and the JCNB.

2. The Secretariat of NAMMCO may, with the concurrence of the Councils of NAMMCO and the JCNB Commissioners, require that statistical material and computing programmes for use in evaluation of the status of stocks or for calculations of catch limits, such as detailed catch and abundance data, be submitted in advance to the Secretariat of NAMMCO in an electronic data storage medium, for validation and ~~preparation prior to the meeting~~ **review**. Submitted statistical material or other raw data shall only be released from the Secretariat of NAMMCO subject to approval of the scientist or Party submitting the data.

VII. Amendments of Rules

1. Proposals for amendment of these Rules of Procedure shall reach the Chairs of the JWG not less than 60 days prior to the JWG meeting at which the matter is to be discussed. The Rules of Procedures must be approved by the Council of NAMMCO and JCNB.

ANNEX 1 - REPORT

Joint Meeting of the

Narwhal Catch Allocation Sub-Group (JWG_{sub})

of the

**NAMMCO SCIENTIFIC COMMITTEE WORKING GROUP ON THE POPULATION STATUS OF
NARWHAL AND BELUGA IN THE NORTH ATLANTIC**

And the

**CANADA/GREENLAND JOINT COMMISSION ON CONSERVATION AND MANAGEMENT OF
NARWHAL AND BELUGA SCIENTIFIC WORKING GROUP**

Copenhagen, Denmark, 10–12 March 2014 and Ottawa, Canada 9-10 March 2015

A sub-group of the NAMMCO-JCNB Joint Scientific Working Group (JWG_{sub}) met 10–12 March 2014 in Copenhagen, Denmark, and again in Ottawa, Canada 9-10 March 2015. The Terms of Reference for this meeting were to:

- review information on distribution, movements and harvest locations of narwhal;
- develop an allocation model that will provide a mechanism for assigning harvested animals to all summer stocks based on existing data;
- specify and quantify exchange rates between aggregations and stocks;
- identify and quantify uncertainty in the allocation model and determine implications for management; and
- recommend future work to resolve uncertainties within the model structure.

The JWG_{sub} agreed that the main purpose for these meetings was to develop a model for catch allocations for the Baffin Bay narwhal population that is shared by Canada and Greenland, but not to decide on the sustainability and/or provide advice on the actual quotas. These issues are for the main Joint Working Group (JWG).

The JWG_{sub} agreed that the model developed during this meeting can be updated with future information (such as abundance estimates and catch statistics) that is approved by the main JWG.

**REVIEW OF INFORMATION ON DISTRIBUTION, MOVEMENTS AND HARVEST LOCATIONS
OF NARWHAL**

Distribution and Movements

Stock structure

The JWG_{sub} discussed new information on stock structure. There was new information to update from Heide-Jørgensen *et al.* (2012). In Canada, narwhals (presumably Somerset Island stock) are moving further west towards Alaska during late summer and were harvested by Cambridge Bay in 2011 and 2012. Other communities that hunt from the Somerset Island stock and have seen an increase in availability of narwhal include Kugaaruk, Taloyoak, and Gjoa Haven and these should be added to the Creswell Bay box on (Fig. 10 from Heide-Jørgensen *et al.* 2012). These hunts are not an issue for creating the model because the catches are from a single stock, i.e., not a mixed stock. These hunts are counted against the Somerset Island quotas.

At the 2015 meeting, Canada informed the group that during the 2013 survey they observed narwhals in Makinson Inlet, which could be attributed to the Smith Sound summer aggregation, but may be a separate aggregation. This subgroup recommends that the main JWG discuss whether to split Makinson Inlet from the Smith Sound aggregation.

The stocks are identified by summer aggregations, which are present in August, however this does not always match with the summer hunt time frames in Canada, which causes difficulties of allocations where the time

frame may encompass migrating periods and summer resident periods. For example, tracking results indicate that AI, ES, and SI narwhal begin movements out of their summer aggregation areas and into adjacent summer aggregation areas at the end of August and into September whereas the summer hunt season dates provided by the Canadian harvest data includes September.

Satellite tracking

Satellite tagging of narwhals has been occurring over the last 20 years. Tagging data are available from many summering grounds except Jones, Smith, East Baffin, and Inglefield Bredning.

Heide-Jørgensen informed the JWG_{sub} that an animal tagged in June 2013 on the southern side of Smith Sound went North of Buchanan Bay. Ferguson added that Canada surveyed this area in 2013.

No new tagging data was available from Canada or Greenland.

Genetic information

No new information was available for genetics of narwhals.

Other information on stock structure

The JWG_{sub} agreed that stable isotope data were reviewed extensively at the last meeting, and that there was no new information to add at this meeting.

Based on this review, the geographical extent of the narwhal summer aggregations used in this model are presented in Fig. 1.

Harvest Locations

The harvest locations used in this model are presented in Fig. 2, which was developed during the 2014 meeting. The location *Central Canadian Arctic* includes the communities of Gjoa Haven, Hall Beach, Igloolik, Kugaaruk, Resolute/Cresswell, Cambridge Bay, and Taloyoak. *Baffin Island Central* includes Clyde River and Qikiqtarjuaq. *Baffin Island South* includes Iqaluit and Pangnirtung.

Following the 2014 meeting, the map of hunting locations was reviewed by other experts in Canada. Greenland compared the map of hunting locations to locations that are received from hunters using GPS indicating where the hunts occurred. These locations are within the hunting regions shown on this map.

The group has determined that the existing map of hunting locations may not reflect the hunt of the same community by different seasons. The group suggests that better information is needed on hunting locations and dates to provide season-specific hunting areas for each regional community hunt.

Catch statistics

Canada informed the JWG_{sub} that they have data on harvest from all localities in Fig. 10 of Heide-Jørgensen *et al.* (2012). Ferguson presented Romberg 2014 (NAMMCO/SC/21-JCNB/SWG/2014-JWG/05) which contained an explanation of revisions to the Canadian narwhal management regime that were implemented in 2013 as a result of the development of an Integrated Fisheries Management Plan, cumulative landed catch information for all Canadian communities that harvested narwhal from 1998–2012, and a detailed breakdown of the seasonal harvest for select Nunavut communities for the period 2003–2012. Lastly, preliminary information was presented for 2013 harvests under the revised narwhal management regime (Tables 1 and 10 in Romberg 2014).

Ferguson also presented Higdon and Ferguson 2014 (NAMMCO/SC/21-JCNB/SWG/2014-JWG/09).

Management seasons in Canada

For Canada, seasons were defined as: Spring = Julian Days 1–204 (1 January to 23 July), Summer = Julian Days 205–274 (24 July to 30 September), and Fall = Julian Days 275–365 (1 October to 31 December) (Romberg and Richard 2005). The JWG_{sub} with support of Canada adopted a winter hunt (1 December – 1 April) to account for narwhal hunted by Pangnirtung and Iqaluit hunters during the same winter period as the Disko Bay hunt.

As mentioned above, harvest information from Canada needs locations and dates to be complete.

The JWG_{sub} recommends that management seasons be reviewed in conjunction with the satellite tagging data, and should be considered relative to narwhal migration patterns. Hunting season dates may vary based on location. The group agreed to define the summer season based on residence of narwhal in the summering grounds.

For Greenland, the seasons are presented in Table 1.

Table 1. Hunting areas in Greenland, and the seasons in which the hunt takes place.

Hunting Area	Hunting Season
Etah	1 May – 1 August
Qaanaaq and Upernavik	1 April – 1 September
Uummannaq	1 November – 1 May
Disko Bay	1 December – 1 April

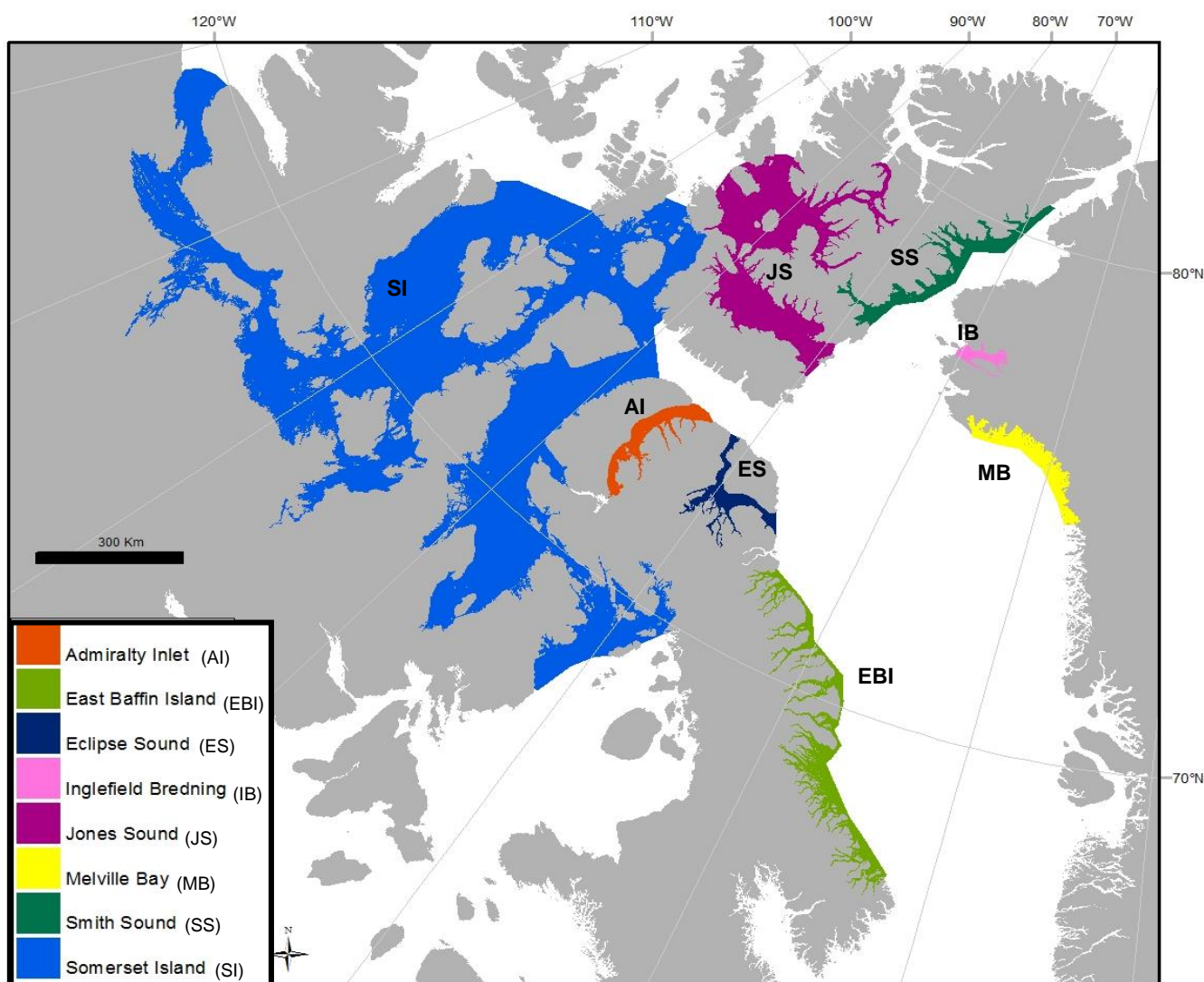


Fig. 1. Map of narwhal summer aggregations used in the model described in this report. Abbreviations in this figure correspond to those in Figures 3 and 4, and Table 3.

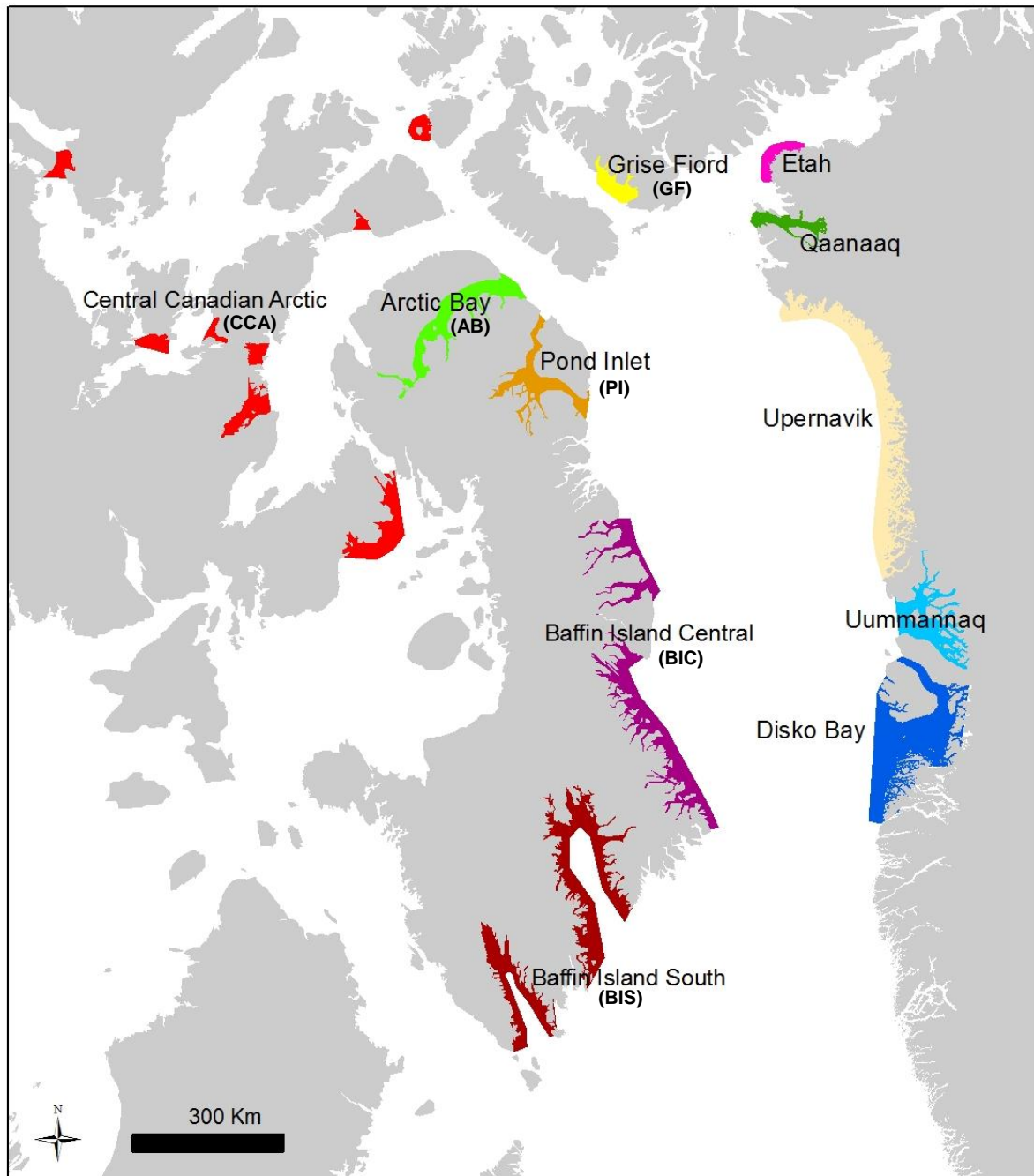


Fig. 2. Map of harvest locations used in the model described in this report. Abbreviations correspond to the abbreviations used in the Figures 3 and 4, and Table 3.

Catch History for the allocation model

Statistics on total removals were used, starting at 1970, a time frame determined by the earliest abundance estimates in Greenland (1981) and Canada (1975). The high option catch history data in Greenland, including struck and lost (1.15 and 1.30) and under-reporting (averages applied to missing information), were from Heide-Jørgensen and Hansen (2012).

Catch history data for Canada for 1970-2013, by community, were taken from Stewart (2009) and updated with recent information provided by Romberg (2014). The percentage catches by season for communities was taken from Romberg (2014) for 2003–2012 and applied retrospectively to the catch data (although as noted previously, management seasons must be revised). The group noted that actual catch dates are needed as input for the model.

Struck and lost

Canada informed the JWG_{sub} that they have not completed the study on struck and lost rates, and still need to come up with struck and lost estimates, including for different seasons. Although data on struck and lost is not available, Grise Fiord is thought to have a low struck and lost rate, mainly due to using a harpoon before shooting.

No new information was available for struck and lost in Greenland.

Values for struck and lost rates are similar in Canada and Greenland since both countries were informed by the same Canadian studies (Weaver and Walker 1988; Roberge and Dunn 1990) except that the unique kayak hunt in Greenland is assumed to have a low loss rate. The group agreed that the main JWG should review the struck and lost data.

Abundance

Information on narwhal population abundance and trends is needed for long-term monitoring and sustainable harvest management. Higdon and Ferguson 2014 (NAMMCO/SC/21-JCNB/SWG/2014-JWG/09) conducted a literature review of surveys and associated abundance estimates for the narwhal summer stocks that occur in Canadian waters (no non-summer surveys were included). Two narwhal populations were assessed, with five summer stocks (four in the Baffin Bay population) as defined by Fisheries and Oceans Canada (DFO). Some stocks are shared with other countries (i.e., Greenland), and some occur in multiple Canadian jurisdictions (e.g., Nunavut and Nunavik). Metadata in the database includes area studied, time frame, survey type, assumptions on availability bias, and use of corrections. The focus was on peer-reviewed scientific publications and government documents where the primary goal was abundance estimation. A number of consulting company reports also detail industry-funded surveys that have been conducted throughout the Canadian Arctic. These surveys are generally conducted for different reasons (impact predictions versus population estimates) and are generally not peer-reviewed. Reports from relevant industry-funded studies are noted in Higdon and Ferguson 2014 (NAMMCO/SC/21-JCNB/SWG/2014-JWG/09) where appropriate but have not been included in the database. The addition of these studies could provide additional abundance estimates that may be useful for trend analyses.

Higdon and Ferguson 2014 (NAMMCO/SC/21-JCNB/SWG/2014-JWG/09) compiled 16 survey records for the five narwhal summer stocks, conducted between 1975 and 2011 (a wide-ranging survey was also conducted in August 2013 and analyses are on-going). Some stocks have been surveyed numerous times and have recent abundance estimates (e.g., Admiralty Inlet, n=5 surveys total, most recently in 2010), others have only have been surveyed once and/or have dated estimates. Several narwhal summer stocks (Somerset Island and East Baffin Island) cover large areas and may have further sub-structuring. Narwhals are also known to occur elsewhere in the Canadian High Arctic during summer (e.g., Parry Islands, Jones Sound), but no surveys have been conducted in these areas (prior to 2013 surveys which are currently being analysed).

Canada informed the group about the recent 2013 High Arctic Cetacean Survey conducted by DFO between August 1 and August 26 2013. The survey teams flew for a combined total of 241 hours and covered most of the summering range of Canadian Baffin Bay narwhal stocks. New abundance estimates based on this synoptic survey will be presented to the main JWG meeting for the Jones Sound, Smith Sound, Somerset Island, Admiralty Inlet, Eclipse Sound and East Baffin summer aggregations.

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The aerial survey was flown using three deHavilland Twin Otter 300 aircraft, each with four observers collecting double-platform sighting data and following line transect survey methods. In addition, photographic records were collected continuously below the aircraft using dual oblique cameras pointing downwards towards either side of the track line. These geo-referenced images will be used to generate separate abundance estimates and will allow the recovery of missing sighting angles from observers, and positive identification of whale species within the frames.

Total narwhal population size in Canada, across all five stocks, is ca. 95–110,000 animals. This estimate may be negatively-biased by lack of coverage of some areas, but many of the estimates are also dated. Trend analyses suggested that populations of narwhal summer stocks are generally stable, although power was low for all tests (Higdon and Ferguson 2014; NAMMCO/SC/21-JCNB/SWG/2014-JWG/09). Results from the 2013 survey, once available, will assist with establishing recent trends in Canadian Arctic narwhal populations. Preliminary results were used during this meeting as current abundance estimates.

The JWG_{sub} agreed that new abundance estimates discussed at this meeting are solely for informational purposes during this meeting to assist in building the model, but formal review of those will be left to the JWG as a whole.

Abundance estimates used in the allocation model for both Greenland and Canada are provided in Table 2. Canadian summer aggregation historic abundance data was taken from Higdon and Ferguson 2014 (NAMMCO/SC/21-JCNB/SWG/2014-JWG/09). A common availability bias was applied to all surveys that provided the total surface observations (2.9 for visual and 3.1 for photographic).

New information from Greenlandic surveys on wintering grounds for narwhals in the North Water was presented at the main JWG meeting (see paper NAMMCO/SC/22-JCNB/SWG/2015-JWG/08 from main JWG 2015 meeting). This group recognizes that these results inform us on distribution, but winter abundances cannot be directly reconciled with summer stocks. However these results indicate that large numbers of narwhal remain in the North Water in winter.

Table 2. Preliminary abundance estimates for summer aggregations of narwhal used in the model. CVs are in parentheses. The most recent abundance estimate was used in the matrix.

Summer Aggregation	Smith Sound	Jones Sound	Inglefield Bredning	Melville Bay	Somerset Island	Admiralty Inlet	Eclipse Sound	East Baffin Island
1975						28,265 (0.22)		
1981					32,523 (0.10)			
1985			3,164 (0.13)			16,402 (0.43)		
1986			8,706 (0.25)					
1996					45,358 (0.35)			
2001			2,297 (0.35)					
2002			1,478 (0.25)		35,806 (0.43)			
2003						5,362 (0.5)		10,073 (0.31)
2004							20,225 (0.36)	
2007			8,368 (0.25)	6,024 (0.86)				
2009	2,309 (1.62)							
2010						18,049 (0.22)		
2012				2,983 (0.39)				
2013	16,360 (0.65)	12,694 (0.33)			49,768 (0.20)	35,043 (0.42)	10,489 (0.24)	17,555 (0.35)
2014				3,091 (0.50)				

Notes:

The surveys from Admiralty Inlet in 1975 and Somerset Island in 1981 were multiplied by 2,919 (cv=0.45, Richard *et al.* 2010) to make them compatible with later surveys that included corrections for perception and availability bias. The Admiralty Inlet survey in 1985 was photographic and therefore a correction of 3.1 was used (Asselin and Richard 2011)

The surveys from Inglefield Bredning in 1985 and 1986 were multiplied by 2,919 (cv=0.45, Richard *et al.* 2010) to make them compatible with later surveys that included corrections for perception and availability bias

The abundance in Smith Sound in 2009 was obtained by subtracting the abundance in Inglefield Bredning from the abundance in the North Water (supposed to include both stocks, Heide-Jørgensen *et al.* 2012)

DEVELOPMENT OF AN ALLOCATION MODEL

This model developed by the JWG_{sub} will provide a mechanism for assigning harvested animals to all summer aggregations based on existing data. The JWG_{sub} assumed for this model that there is no exchange between summer aggregations.

The main purpose of the model is to give management advice; suggest sustainable harvest levels/allocations. The group agreed that the model is also a tool that can be used for retrospective and forecasting analyses in addition to quota allocation. Retrospective analysis could include investigating the effects of past hunting on narwhal population abundance estimates. Future analysis could include how changes in proposed harvest scenarios could affect population abundances.

The model was developed in the form of a 24 rows by 8 columns allocation matrix. The eight columns were the individual summer aggregations of Smith Sound, Jones Sound, Inglefeld Bredning, Melville Bay, Somerset Island, Admiralty Inlet, Eclipse Sound, and East Baffin Island (locations shown in Fig. 1). The 24 rows represented 24 hunts divided by 10 regions and for some regions hunts were divided by season (Fig. 2). Thus for each summer aggregation and hunt there is a cell in the matrix, and the matrix is devised so that when multiplied by a vector of removals, the resulting vector will determine the total removals from each summer aggregation, described below.

Each cell of the allocation matrix, \mathbf{A} , had the value:

$$\mathbf{A}_{ijt} = \frac{\mathbf{P}_{ij} N_{it}}{\sum_i \mathbf{P}_{ij} N_{it}}$$

Where,

\mathbf{A}_{ijt} is the proportion of the j th hunt that is assigned to the i th summer aggregation in year t .

\mathbf{P}_{ij} is the proportional availability of the i th summer aggregation to the j th hunt.

N_{it} is the abundance of the i th summer aggregation in year t .

This model assumes that for each summer aggregation there is a proportion between zero and one, \mathbf{P}_{ij} , that is available to hunters during the hunting period on the hunting grounds. Each individual that is available is then at equal risk of being taken in the hunt. The sum of the \mathbf{A}_{ijt} should be 1 for each row of \mathbf{A}_t .

To set up the proportional availability matrix, \mathbf{P} , we reviewed each cell so that each cell in the matrix was given one of five designations:

Zero Availability ("hard zero"): This designated cells that represented improbable situations such as a summer harvest that was not at a summering ground (e.g. a narwhal harvested in summer in Resolute could not come from the Smith Sound summer aggregation and would be assigned to Somerset Island stock) and to hunts in areas that could not have originated in a particular summering ground based on known movements.

Unlikely Availability ("soft zero"): This designated cells in which a summering aggregation was unlikely to be hunted but proximity during the hunting season, or a presumed migration route did not rule out possible catches and designated cells with no tag data.

Partial availability (based on tagging data): This designated cells with tag data showing a portion of the summering aggregation was available or not to hunters.

Expected availability ("soft one"): This designated cells in which a summering aggregation was likely to be fully available to a hunt, based on its geographical proximity to a summering ground or migration route, but for which there was no quantitative evidence such as tag data.

Complete availability ("hard one"): This designated cells representing hunts on summering grounds or known wintering areas of summering aggregations.

Proportional Availability Matrix

Two versions of the proportional availability matrix were considered with different treatments of each designation. In the fixed version, both *Zero Availability* and the *Unlikely Availability* were given the value zero and both the *Expected Availability* and *Complete Availability* were given the value one. As outlined below, the *Partial Availability* hunts were given values resulting from tag data as the fraction of the possible tags that went into the hunt area. The second version is a stochastic matrix in which the value for each cell is drawn from a distribution as described in the sensitivity analysis.

The fixed matrix can be used to provide single value results. The stochastic matrix can be used for sensitivity analysis and risk assessment on its own or with a stochastic vector of abundance estimates or hunt takes.

With the development of A_t , the full model is then:

$$S_t = A_t H_t$$

Where,

S_t is a vector of the number of narwhal taken in hunts from each summer aggregation in year t .

A_t is the A matrix in year t .

H_t is a vector of the numbers of narwhal taken in hunts at each hunting area by season in year t .

As noted above, both P_{ij} and N_{it} may be stochastic, thus S_t would be stochastic as well. Stochastic versions of P_{ij} and N_{it} are considered below in the sensitivity analysis. The group discussed the point that as more movement data becomes available from satellite tracking experiments the P matrix will be modified and if behavioural changes are suspected over time the P matrix will become time dependent as well. One suggestion was to weight the most recent tag data more heavily and decreasing the weight with the age of the data in comparison to the year of the P matrix. This can also be done for a P matrix for a past year with newer data being given lower weight than the years around the time of the P matrix.

The group discussed two uses of the model but deferred further discussion to the full JWG, these were:

1. Modification to estimate the removals as a fraction of each summering stock so that S^* is a vector of the fraction of a summering stock taken by hunting with elements $S_{it}^* = S_{it}/N_{it}$ or if the A matrix is modified, $S^* = A^* H$ where,

$$A_{ijt}^* = \frac{P_{ij}}{\sum_i P_{ij} N_{it}}$$

2. The reverse problem of estimating sustainable take limits from take on summering aggregations. The group noted that the reverse problem of estimating recommended limits for individual hunts is under specified so further information regarding how optimum hunt quotas or limits are defined is necessary before a single result can be identified. Alternatively the reverse problem could identify a range of limits that would be equivalent for sustainability or limiting risk and then managers could use other criteria to choose among these.

SPECIFICATION AND QUANTIFICATION OF EXCHANGE RATES AMONG AGGREGATIONS

To determine the proportional availability of each summer aggregation in the different hunting regions (P_{ij}) value, we used satellite tracking data where available, and data on distribution and movements where satellite tracking was insufficient.

Rules for assigning risk of taking in a hunt using the narwhal tag data

The following rules were developed by the JWG_{sub}. Individual decisions on each cell in the matrix are provided in Appendix CA1.

1. Narwhal satellite-tagged during the summer are assumed to belong to the aggregation where they were tagged. This is thought to be generally true but one example of a movement between summer stocks in subsequent years and early departure on migration during the last week of August and early September have occurred. These were designated as “*Complete Availability*” on their summering grounds and “*Zero Availability*” to summer hunts outside of the summering grounds.
2. Narwhal tagged in other seasons are used if the tags last long enough to record a movement to a summering area. In the case of Uummannaq these were interpreted as a connection but could not be used to estimate a probability, however Somerset Island was the only summer stock related to Uummannaq by tag data.
3. Currently, we define sample weight as one for each tag that entered the hunting season. In the future, the weight will be the number of days in a hunting season until the last transmission of the tag during the season divided by the total number of days comprising the hunting season, so that a tag lasting through the season has a weight of 1 and a tag that fails prior to the season has a weight of 0.
4. Sample size for tag data is the sum of the tags that originated in a summering ground and lasted until the beginning day of hunting multiplied by their weight (see #3).
5. The number of narwhals at risk of hunting is the sum of the number of narwhals that entered the hunting area at least once during the hunting season multiplied by their weight from item 3. An example would be the 3 tags last into the hunting season 2 last through the season one enters the hunting area the other doesn't. The third whale lasts through half the season but enters the hunting area. The sample is then

$$Y=(1*1+1*1+1*0.5)=2.5: \text{ the number at risk is then } X=(1*1+0*1+1*0.5)=1.5$$

6. These proportions were calculated using the number of whales (X) tracked from a summer aggregation that visited a hunting region during the hunting season. X was then divided by the number of tagged whales that were transmitting at that time (Y) that had originated in the summer aggregation. For instance, continuing the example in Item 5, this would be $1.5/2.5$.
7. Currently, for those designated as *Partial Availability*, decisions to ascertain whether a tracked whale entered the area “available” to the hunters of a given community were based on review of its trajectory and by the JWG_{sub}. In the future, a narwhal is considered to have entered a hunting area, if any good quality location or trackline (i.e. only ARGOS quality 1,2,3 locations) buffered by 10km falls within the hunting area. In cases where the trackline crosses land, these will be reviewed to determine whether it is in close proximity to a hunting area.
8. Hunting areas are defined based on the areas utilized by hunters in each season. Ideally this is based either on location data from takes or on local knowledge and observations.
9. Hunting takes are assigned by season to the area of a community hunt. In some cases hunters take narwhal in other areas these should be assigned to the area of take rather than the community.

10. When tag data is not available Expert opinion is used based on: 1) seasonal distribution observation from surveys, 2) traditional knowledge and expert understanding of animal movements 3) proximity to hunting areas, 4) by analogy to other stocks presumed to have similar migration patterns.
11. Cells with *Zero Availability* and *Unlikely Availability* were assigned a proportional availability of 0. By definition, all summer stocks had a proportional availability of 1 for the summer hunt occurring within their own summer range (*Complete Availability*). Cells with *Expected Availability* were also given a proportion of 1.

Applying the 11 rules above to the hunts and summer aggregations results in the deterministic version of the matrix shown in Table 3 (see also Appendix CA1).

IDENTIFY AND QUANTIFY UNCERTAINTY IN THE ALLOCATION MODEL AND DETERMINE IMPLICATIONS FOR MANAGEMENT

There are two main sources of uncertainty in the analysis: uncertainty in the proportion of whales from one stock that are available to hunters at a given hunting site (P_{ij}), and errors in stock abundance estimates from aerial surveys (N_{it}). We integrated them in the allocation model and quantified their impact on the removal vectors.

Uncertainty in the proportional availability matrix P

We quantified uncertainty around proportions P_{ij} by assuming that the number of whales located in a certain area followed a binomial distribution with a sample size equal to the number of transmitting tags (Y) and a probability equal to the true proportion of the summer aggregation that visits this area. This true proportion is unknown but follows a beta distribution, $Beta(X+1, Y-X+1)$ (Johnson and Kotz, 1970), where X is the number of transmitting tags that visited the hunting area.

When no movements were documented between a summer aggregation and a hunting ground, we distinguished between movements that were deemed extremely unlikely based on expert knowledge, and movements that were considered unlikely but not impossible. As described in the previous section, the former, designated as *Zero Availability*, were assigned a proportional availability of 0, with no uncertainty. The latter, designated as *Unlikely Availability*, were also assigned a proportional availability of 0, but were given a $Beta(1, Z+1)$ probability distribution, where Z is an uncertainty parameter that can vary from 1 to infinity (larger values represent lower uncertainty). Cells with *Expected Availability* were given a $Beta(Z+1, 1)$ distribution. In practice the parameter Z can be thought of as a hypothetical number of transmitting tags that would result in no tags visiting a hunting area, thus a minimum value for Z would be the number of tags to date and higher values would reflect certainty resulting from other sources. For this exercise this parameter was used for sensitivity testing of the model, setting Z to be identical for all cells designated as *Unlikely Availability* assuming $Z=10,000$ as the base case (i.e., no uncertainty).

Inclusion of uncertainty changes P_{ij} from a table with fixed values to a table in which each cell contains a probability distribution (Table 4). For cells with *Zero Availability* and *Complete Availability*, these distributions have essentially zero variance and result in a single value of 0 or 1, respectively. Cells with *Partial Availability* show a distribution with mean equal to the corresponding value in the fixed version of the table, and which variance reflects uncertainty around this value.

For cells with *Unlikely Availability*, both mean and variance depend on the value of Z . The maximum value of $Z=10,000$ results in a distribution identical to *Zero Availability*. Lower values of Z result in larger means and larger coefficients of variation.

Table 3. Proportional availability matrix P (deterministic version). Each cell describes the availability of narwhals from summer aggregations to hunting regions. Black numbers represent “hard” zeros and ones, red numbers are “soft” zeros and ones, and blue numbers are based on the proportion of tracked whales that visited a hunting region, as described in rule 6.

Hunt	Season	Summer Aggregation							
		Smith	Jones	Inglefeld	Melville	Somerset	Admiralty	Eclipse	East
		Sound	Sound	Bredning	Bay	Island	Inlet	Sound	Baffin
Qaanaaq	Spring	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Qaanaaq	Summer	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Grise Fjord	Spring	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Grise Fjord	Summer	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Grise Fjord	Fall	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Upernavik	Summer	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
Uummannaq	Fall	0.00	0.00	0.00	0.11	1.00	0.00	0.00	0.00
Disko Bay	Winter	0.00	0.00	0.00	0.14	0.00	0.02	0.17	0.00
CCA	Spring	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
CCA	Summer	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
CCA	Fall	0.00	0.00	0.00	0.00	1.00	0.17	0.04	0.00
Arctic Bay	Spring	0.00	0.00	0.00	0.00	1.00	1.00	0.20	0.00
Arctic Bay	Summer	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
Arctic Bay	Fall	0.00	0.00	0.00	0.00	0.00	1.00	0.23	0.00
Pond Inlet	Spring	0.00	0.00	0.00	0.00	1.00	1.00	1.00	0.00
Pond Inlet	Summer	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
Pond Inlet	Fall	0.00	0.00	0.00	0.00	0.00	0.10	1.00	0.00
BIC	Spring	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
BIC	Summer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
BIC	Fall	0.00	0.00	0.00	0.00	0.00	0.24	0.62	1.00
BIS	Spring	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
BIS	Summer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
BIS	Fall	0.00	0.00	0.00	0.00	0.00	0.00	0.08	1.00
BIS	Winter	0.00	0.00	0.00	0.00	0.00	0.00	0.17	1.00

Table 4. Proportional availability matrix P (stochastic version). Each cell describes the availability of narwhals from summer aggregations to hunting regions [X/Y: available (X) over total (Y)]. Black numbers are fixed, blue and red are beta distributions ($\alpha = X+1$; $\beta = Y-X+1$); red cells are sensitive to changes in uncertainty parameter Z.

Hunt	Season	Summer Aggregation							
		Smith	Jones	Inglefeld	Melville	Somerset	Admiralty	Eclipse	East
		Sound	Sound	Bredning	Bay	Island	Inlet	Sound	Island
Qaanaaq	Spring	1	0/Z	0	0	0	0	0	0
Qaanaaq	Summer	0	0	1	0	0	0	0	0
Grise Fjord	Spring	0/Z	1	0/Z	0	0/Z	0	0	0
Grise Fjord	Summer	0	1	0	0	0	0	0	0
Grise Fjord	Fall	0/Z	1	0/Z	0	0/Z	0	0	0
Upernavik	Summer	0	0	0	1	0	0	0	0
Ummannaq	Fall	0/Z	0/Z	0/Z	1/9	1	0/42	0/26	0/Z
Disko Bay	Winter	0/Z	0/Z	0/Z	1/7	0/Z	1/42	1/6	0/Z
CCA	Spring	0	0	0	0	1	0/4	0/5	0
CCA	Summer	0	0	0	0	1	0	0	0
CCA	Fall	0	0	0	0	1	1/6	1/26	0
Arctic Bay	Spring	0	0	0	0	1	1	1/5	0
Arctic Bay	Summer	0	0	0	0	0	1	0	0
Arctic Bay	Fall	0	0	0	0	0/Z	1	6/26	0
Pond Inlet	Spring	0	0/Z	0/Z	0	2/2	4/4	1	0/Z
Pond Inlet	Summer	0	0	0	0	0	0	1	0
Pond Inlet	Fall	0	0/Z	0/Z	0	0/14	4/42	1	0/Z
BIC	Spring	0	0/Z	0/Z	0	0/2	0/4	0/6	1
BIC	Summer	0	0	0	0	0	0	0	1
BIC	Fall	0	0/Z	0/Z	0	0/5	5/21	8/13	1
BIS	Spring	0	0	0	0	0/2	0/4	0/6	Z/Z
BIS	Summer	0	0	0	0	0	0	0	1
BIS	Fall	0	0	0	0	0/5	0/42	1/13	Z/Z
BIS	Winter	0	0	0	0	0/2	0/42	1/6	Z/Z

Integrating uncertainty in abundance vectors N_{it}

Abundance estimates with a given mean (N) and coefficient of variation (CV) were assumed to follow a log-normal distribution with parameters μ and σ given by:

$$\mu = \log \frac{N^2}{\sqrt{N^2(1 + CV^2)}}$$

and

$$\sigma = \sqrt{\log(1 + CV^2)}$$

To integrate uncertainty in abundance vectors N_{it} in the allocation matrix \mathbf{A}_{ijt} , we used Monte-Carlo sampling. We drew 100,000 samples from a beta distribution for each cell in \mathbf{P}_{ij} and 100,000 samples from a lognormal distribution for each value of N_{it} . We then calculated the value of \mathbf{A}_{ijt} for each cell and each sample. The resulting distributions thus include the full uncertainty in proportional availabilities and abundance estimates (Fig. 3 for $Z=10,000$ and Fig. 4 for $Z=1$).

Effect of uncertainty on removals

After integrating uncertainty in *Partial Availability*, *Unlikely Availability*, and *Expected Availability* distributions from matrix \mathbf{P} , as well as uncertainty in abundance vectors, the removals from each stock now have an error distribution (rather than being fixed values). Table 5 shows mean removals and associated coefficients of variation. Uncertainty around *Unlikely Availability* proportions depend on Z , and therefore Z also has an effect on the mean value of removal vectors. One example of this effect is shown for the Admiralty Inlet and East Baffin Island stocks (Fig. 5): when uncertainty increases, a larger part of the Pond Inlet catch is redistributed to the Somerset Island and East Baffin stocks, thus reducing total removals from Admiralty Inlet. If we think of Z in terms of the tag data, when Z is large compared to the number of tags then the results are insensitive to Z . When Z is similar to or smaller than the number of tags, the results are highly sensitive to Z . Thus the application of this matrix will require careful consideration of the lower bounds for Z in individual cells and demonstrates the need for more tagging data in summering aggregations where the allocation matrix is most sensitive.

Determining the management implications of the allocation model is deferred to the JWG.

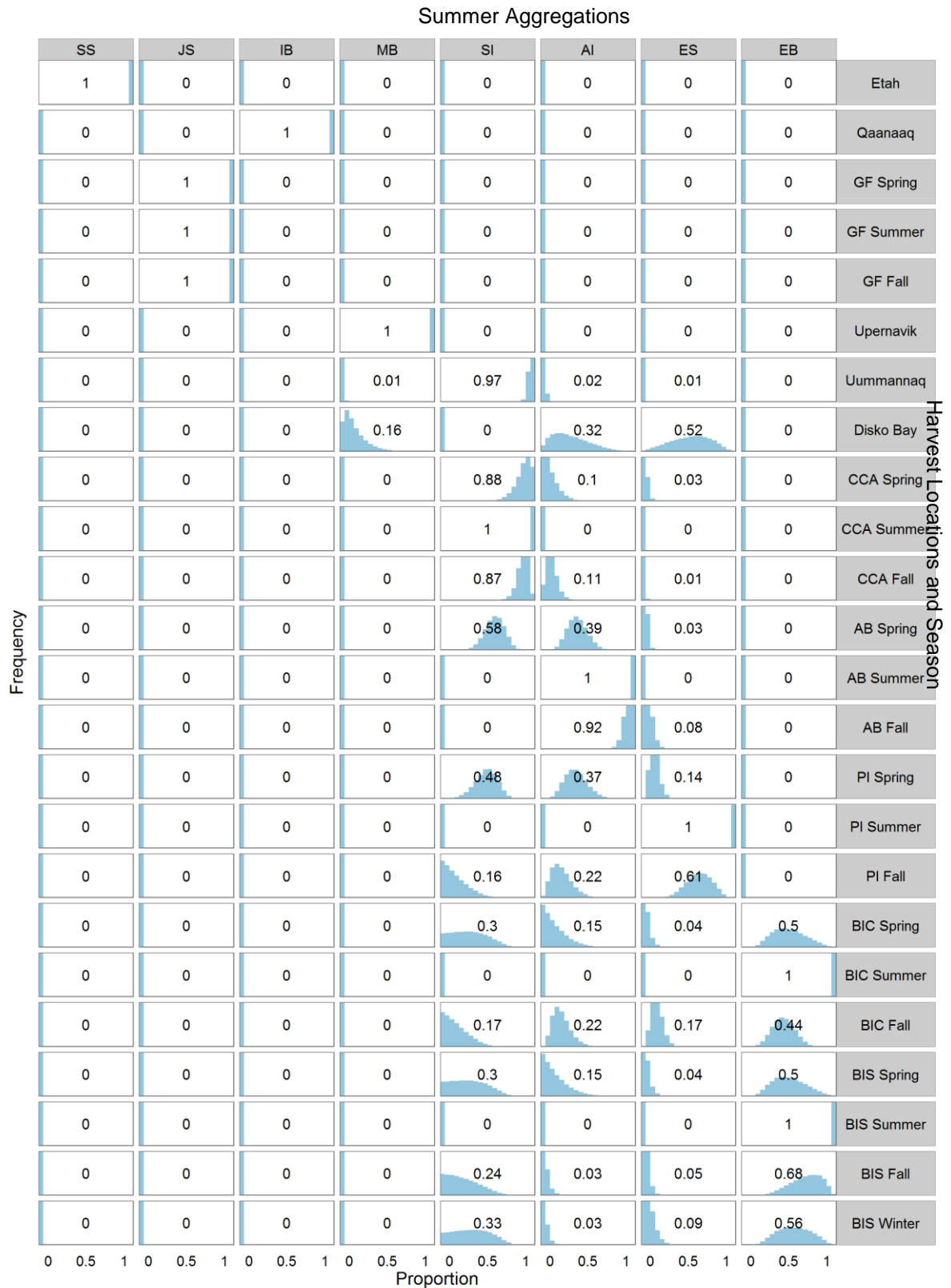


Figure 3. Allocation matrix A_{ij} with uncertainty in *Partial Availabilities* and no uncertainty in *Unlikely* and *Expected Availabilities* ($Z = 10,000$). Abbreviations are defined in Figures 1 and 2.

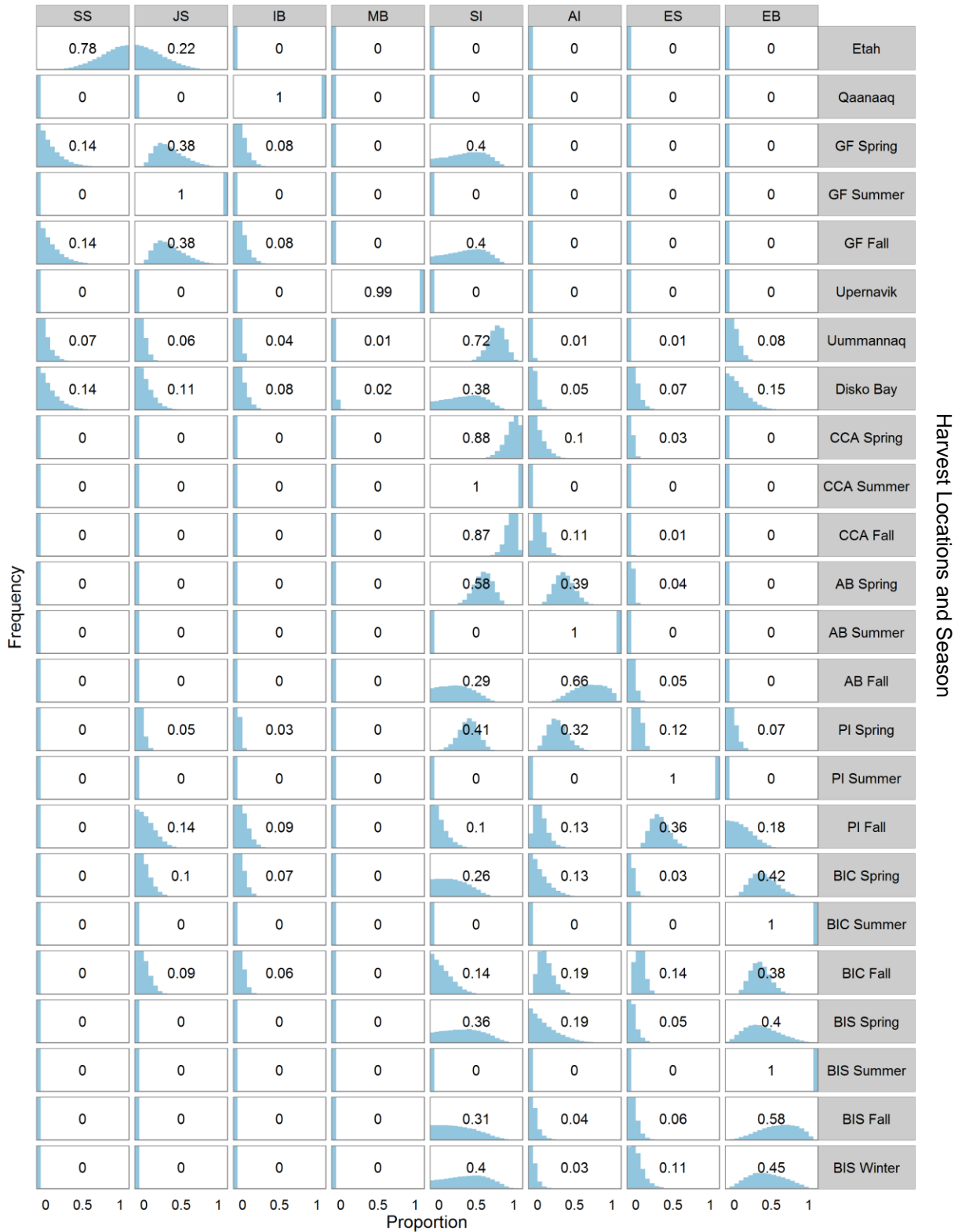


Figure 4. Allocation matrix A_{ij} with uncertainty in *Partial Availabilities* and $Z = 1$ for quantifying uncertainty in *Unlikely* and *Expected Availabilities*. Abbreviations are defined in Figures 1 and 2.

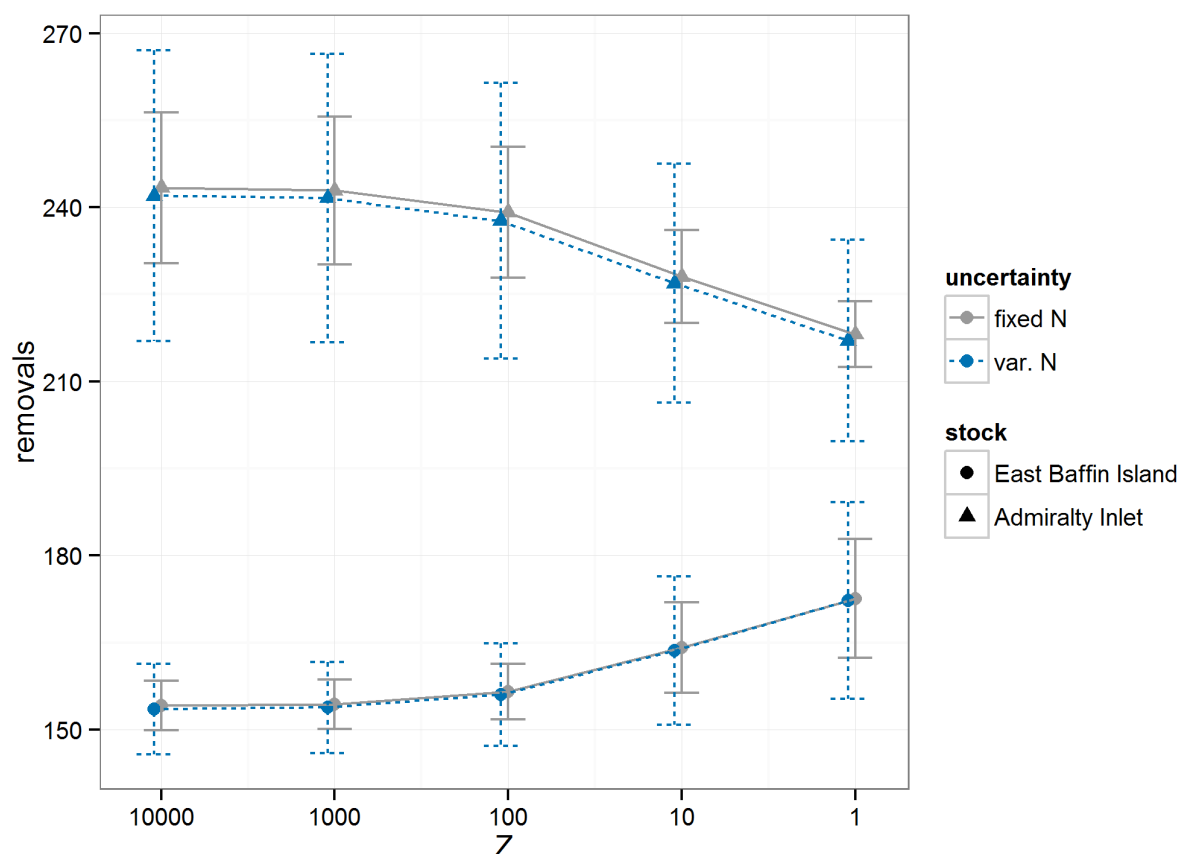


Figure 5. Effect of Z and uncertainty in abundance estimates on removals (\pm SD) from the AI and EB stocks, based on allocation of 2013 Greenland and Canadian catches. Fixed N: assuming no uncertainty in abundance estimates. Var. N: including uncertainty in abundance estimates. Uncertainty in *Unlikely Availability* proportions increases as Z decreases.

Table 5. Removals (and CV%) from each stock based on allocation of 2013 Greenland and Canadian catches, under several assumptions. Z=10,000: including uncertainty in *Partial Availability* proportions but assuming no uncertainty for *Unlikely Availability*. Z=1: including maximum uncertainty for *Unlikely availability*. Fixed N: assuming no uncertainty in abundance estimates. Var. N: including uncertainty in abundance estimates.

Stocks	SS	JS	IB	MB	SI	AI	ES	EB
Deterministic	0	9	87	93	230	243	170	154
Z=10,000 fixed N	0 (0%)	9 (1%)	87 (0%)	93 (7%)	230 (4%)	243 (5%)	170 (7%)	154 (3%)
Z=1 fixed N	18 (49%)	31 (26%)	103 (5%)	84 (1%)	225 (7%)	218 (3%)	136 (3%)	173 (6%)
Z=10,000 var. N	0 (0%)	9 (1%)	87 (0%)	93 (9%)	232 (7%)	242 (10%)	171 (10%)	154 (5%)
Z=1 var. N	17 (72%)	31 (36%)	103 (7%)	84 (2%)	226 (11%)	217 (8%)	136 (6%)	172 (10%)

RECOMMENDATIONS FOR FUTURE WORK TO RESOLVE UNCERTAINTIES WITHIN THE MODEL STRUCTURE

- 1) The JWG_{sub} recommends that the JWG review the sensitivity analysis and identifies key components that will improve the model. For example, sensitivity analysis could help identify where increased sample sizes of telemetry data could be useful.
- 2) The JWG_{sub} recommends considering alternative methods of stock identification such as genetics, stable isotopes, etc. as they become available.
- 3) The JWG_{sub} recognises that small sample sizes of satellite tag data includes uncertainty that further tagging efforts would reduce. Additional satellite tagging should be undertaken, especially in areas where no tagging or limited tagging data has been collected.
- 4) The JWG_{sub} recommends that the JWG address the generation of management advice using the allocation model.

Tasks for the next JWG meeting:

- 1) Complete sensitivity analysis of the matrix to identify points of uncertainty critical to management advice (Witting).
- 2) Define hunt seasons and hunt areas individually (e.g., each hunt season may have different areas hunted), using hunter knowledge and GPS locations of takes (where available). (Ferguson)
- 3) Analyse telemetry tracking data to provide consistent maps of all tagged narwhal; thereby providing future review of each whale individually and calculating the proportion of time each whale was tracked within a season. (Hansen will write script, Watt has provided Canadian data from 2009 to 2012).

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Appendix 1

Appendix CA1. Table of decisions on assigning proportions. Note that in a few cases (*notes in italics*) the JWG_{sub} made a preliminary determination based on incomplete data or noting a discrepancy in dates of a hunt on migrating narwhal with the dates of migration. These were left to the JWG to resolve at a later meeting but none were considered critical to the use of the allocation matrix.

Stock	Site	Prop	Comment
Admiralty Inlet	Etah (Qaanaaq spring)	Hard 0	based on likely migration patterns
Admiralty Inlet	Qaanaaq	Hard 0	unlikely movement
Admiralty Inlet	GF Spring	Hard 0	unlikely movement
Admiralty Inlet	GF Summer	Hard 0	by definition of summer aggregations
Admiralty Inlet	GF Fall	Hard 0	unlikely movement
Admiralty Inlet	Upernavik (summer)	Hard 0	by definition of summer aggs
Admiralty Inlet	Uummannaq	Hard 0	based on tag data (0/42)
Admiralty Inlet	Disko Bay (winter)	Soft 0	based on tag data (1/42)
Admiralty Inlet	CCA Spring	Hard 0	based on migration patterns not likely they would go there in spring, none of the tagged animals
Admiralty Inlet	CCA Summer	Hard 0	by definition of summer aggregations
Admiralty Inlet	CCA Fall	0.166667	tagged data
Admiralty Inlet	AB Spring	Hard 1	by definition of summer aggregations
Admiralty Inlet	AB Summer	Hard 1	by definition of summer aggregations
Admiralty Inlet	AB Fall	Hard 1	by definition of summer aggregations
Admiralty Inlet	PI Spring	Hard 1	tag data (4/4 tagged animals went there), but migration pattern hugs coast and hunters behaviour (floe edge hunt)
Admiralty Inlet	PI Summer	Hard 0	by definition of summer aggregations
Admiralty Inlet	PI Fall	0.095238	tagged data (4/42) <i>Catch season dates need to be revisited because they do not fit with the timing of migration</i>
Admiralty Inlet	BIC Spring	0	no tagged animals there (0/4)
Admiralty Inlet	BIC Summer	Hard 0	by definition of summer aggregations
Admiralty Inlet	BIC Fall	0.238095	10 tags out of 42
Admiralty Inlet	BIS Spring	0	0/4 tags nearby
Admiralty Inlet	BIS Summer	Hard 0	by definition of summer aggregations
Admiralty Inlet	BIS Fall	0	0/42 tagged animals nearby
Admiralty Inlet	BIS Winter	0	0/42 tagged animals nearby
East Baffin Island	Etah (Qaanaaq spring)	Hard 0	likely movement
East Baffin Island	Qaanaaq	Hard 0	likely movement
East Baffin Island	GF Spring	Hard 0	likely movement
East Baffin Island	GF Summer	Hard 0	by definition of summer aggregation
East Baffin Island	GF Fall	Hard 0	likely movement
East Baffin Island	Upernavik	Hard 0	likely movement
East Baffin Island	Uummannaq	Soft 1	geographically close, analogy with other migrating stocks
East Baffin Island	Disko Bay	Soft 0	geographically close, analogy with other migrating stocks

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Stock	Site	Prop	Comment
East Baffin Island	CCA Spring	Hard 0	unlikely movement
East Baffin Island	CCA Summer	Hard 0	by definition of summer aggregation
East Baffin Island	CCA Fall	Hard 0	unlikely movement
East Baffin Island	AB Spring	Hard 0	unlikely movement
East Baffin Island	AB Summer	Hard 0	by definition of summer aggregation
East Baffin Island	AB Fall	Hard 0	unlikely movement
East Baffin Island	PI Spring	Soft 0	based on proximity
East Baffin Island	PI Summer	Soft 0	based on proximity
East Baffin Island	PI Fall	Soft 0	based on proximity
East Baffin Island	BIC Spring	Hard 1	likely movement
East Baffin Island	BIC Summer	Hard 1	by definition of summer aggregation
East Baffin Island	BIC Fall	Hard 1	likely movement
East Baffin Island	BIS Spring	Soft 1	not sure what other animals could contribute significantly
East Baffin Island	BIS Summer	Hard 1	by definition of summer aggregation, only animals available to summer hunt
East Baffin Island	BIS Fall	Soft 1	not sure what other animals could contribute significantly
East Baffin Island	BIS Winter	Soft 1	not sure what other animals could contribute significantly
Eclipse Sound	Etah (Qaanaaq spring)	Hard 0	unlikely movement
Eclipse Sound	Qaanaaq	Hard 0	by definition of summer aggregations
Eclipse Sound	GF Spring	Hard 0	unlikely movement
Eclipse Sound	GF Summer	Hard 0	unlikely movement
Eclipse Sound	GF Fall	Hard 0	unlikely movement
Eclipse Sound	Upernavik	Hard 0	unlikely movement
Eclipse Sound	Uummannaq	Hard 0	0/26 tagged animals
Eclipse Sound	Disko Bay	0.166667	1/6 tagged animals
Eclipse Sound	CCA Spring	Hard 0	0/5 tagged animals
Eclipse Sound	CCA Summer	Hard 0	by definition of summer aggregations
Eclipse Sound	CCA Fall	Soft 0	1/26 tagged animals
Eclipse Sound	AB Spring	0.2	1/5 tagged animals
Eclipse Sound	AB Summer	Hard 0	By definition of summer aggregations. <i>There was one animal tagged in 2010 in Eclipse Sound with a satellite transmitter that lasted until October 2011 that returned from the winter range to summer in Admiralty Inlet, but all other expert opinion says this violates the rule that summer animals stay within their summer aggregation. In future, perhaps Admiralty and Eclipse should be one stock. For precautionary management purposes right now they are considered two stocks.</i>
Eclipse Sound	AB Fall	0.230769	6/26 tagged animals
Eclipse Sound	PI Spring	Hard 1	likely movement
Eclipse Sound	PI Summer	Hard 1	by definition of summer aggregations
Eclipse Sound	PI Fall	Hard 1	likely movement

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Stock	Site	Prop	Comment
Eclipse Sound	BIC Spring	0	likely movement
Eclipse Sound	BIC Summer	Hard 0	by definition of summer aggregations
Eclipse Sound	BIC Fall	0.615385	tagged animals
Eclipse Sound	BIS Spring	0	tag data (0/6)
Eclipse Sound	BIS Summer	Hard 0	by definition of summer aggregations
Eclipse Sound	BIS Fall	0.076923	2/26 tagged animals
Eclipse Sound	BIS Winter	0	tagged animals (1/6) <i>Check Dates</i>
Inglefield Bredning	Etah (Qaanaaq spring)	Hard 0	unlikely movement
Inglefield Bredning	Qaanaaq	Hard 1	based on summer aggregations
Inglefield Bredning	GF Spring	Soft 0	unlikely movement
Inglefield Bredning	GF Summer	Hard 0	unlikely movement
Inglefield Bredning	GF Fall	Soft 0	could be hunted by GF in fall
Inglefield Bredning	Upernavik	Hard 0	unlikely movement
Inglefield Bredning	Uummannaq	Hard 0	unlikely movement
Inglefield Bredning	Disko Bay	Soft 0	unlikely movement
Inglefield Bredning	CCA Spring	Hard 0	unlikely movement
Inglefield Bredning	CCA Summer	Hard 0	by definition of summer aggregations
Inglefield Bredning	CCA Fall	Hard 0	unlikely movement
Inglefield Bredning	AB Spring	Hard 0	unlikely movement
Inglefield Bredning	AB Summer	Hard 0	by definition of summer aggregations
Inglefield Bredning	AB Fall	Hard 0	unlikely movement
Inglefield Bredning	PI Spring	Hard 0	unlikely movement
Inglefield Bredning	PI Summer	Hard 0	by definition of summer aggregations
Inglefield Bredning	PI Fall	Soft 0	unlikely movement
Inglefield Bredning	BIC Spring	Hard 0	unlikely movement
Inglefield Bredning	BIC Summer	Hard 0	by definition of summer aggregations
Inglefield Bredning	BIC Fall	Hard 0	unlikely movement
Inglefield Bredning	BIS Spring	Hard 0	unlikely movement
Inglefield Bredning	BIS Summer	Hard 0	by definition of summer aggregations
Inglefield Bredning	BIS Fall	Hard 0	unlikely movement
Inglefield Bredning	BIS Winter	Hard 0	unlikely movement
Jones	Etah (Qaanaaq spring)	Soft 0	unlikely movement
Jones	Qaanaaq (summer stock)	Hard 0	all Jones animals are in Jones
Jones	GF Spring	Hard 1	likely migration pattern
Jones	GF Summer	Hard 1	by definition of summer aggregations
Jones	GF Fall	Hard 1	likely migration pattern
Jones	Upernavik	Soft 0	unlikely movement
Jones	Uummannaq	Soft 0	based on behaviour similar to other summering stocks on the west side of Baffin Bay
Jones	Disko Bay	Soft 0	based on behaviour similar to other summering stocks on the west side of Baffin Bay
Jones	CCA Spring	Hard 0	unlikely movement

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Stock	Site	Prop	Comment
Jones	CCA Summer	Hard 0	by definition of summer aggregations
Jones	CCA Fall	Hard 0	unlikely movement
Jones	AB Spring	Hard 0	unlikely movement
Jones	AB Summer	Hard 0	by definition of summer aggregations
Jones	AB Fall	Hard 0	unlikely movement
Jones	PI Spring	Soft 0	by analogy with other stocks that move to central Baffin
Jones	PI Summer	Hard 0	by definition of summer aggregations
Jones	PI Fall	Hard 0	by analogy with other stocks that move to central Baffin
Jones	BIC Spring	Hard 0	unlikely movement
Jones	BIC Summer	Hard 0	by definition of summer aggregations
Jones	BIC Fall	Hard 0	unlikely movement
Jones	BIS Spring	Hard 0	unlikely movement
Jones	BIS Summer	Hard 0	by definition of summer aggregations
Jones	BIS Fall	Hard 0	unlikely movement
Jones	BIS Winter	Hard 0	unlikely movement
Melville Bay	Etah (Qaanaaq spring)	Hard 0	unlikely movement
Melville Bay	Qaanaaq	Hard 0	unlikely movement
Melville Bay	GF Spring	Hard 0	unlikely movement
Melville Bay	GF Summer	Hard 0	by definition of summer aggregations
Melville Bay	GF Fall	Hard 0	unlikely movement
Melville Bay	Upernavik (summer)	Hard 1	by definition of summer aggregations
Melville Bay	Uummannaq	Soft 0	tag data
Melville Bay	Disko Bay	0.142857	tag data
Melville Bay	CCA Spring	Hard 0	unlikely movement
Melville Bay	CCA Summer	Hard 0	by definition of summer aggregations
Melville Bay	CCA Fall	Hard 0	unlikely movement
Melville Bay	AB Spring	Hard 0	unlikely movement
Melville Bay	AB Summer	Hard 0	by definition of summer aggregations
Melville Bay	AB Fall	Hard 0	unlikely movement
Melville Bay	PI Spring	Hard 0	unlikely movement
Melville Bay	PI Summer	Hard 0	by definition of summer aggregations
Melville Bay	PI Fall	Hard 0	unlikely movement
Melville Bay	BIC Spring	Hard 0	unlikely movement
Melville Bay	BIC Summer	Hard 0	by definition of summer aggregations
Melville Bay	BIC Fall	Hard 0	unlikely movement
Melville Bay	BIS Spring	Hard 0	unlikely movement
Melville Bay	BIS Summer	Hard 0	by definition of summer aggregations
Melville Bay	BIS Fall	Hard 0	unlikely movement
Melville Bay	BIS Winter	Hard 0	unlikely movement
Smith Sound	Etah (Qaanaaq spring)	Hard 1	Based on one tagged animal data, and Etah hunting site is ice edge hunting site in Smith Sound
Smith Sound	Qaanaaq	Hard 0	animals are in Ingelfeld Bredning

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Stock	Site	Prop	Comment
Smith Sound	GF Spring	Soft 0	<i>Uncertainty of timing of hunt and movement of animals. JWG_{sub} unsure of whether SS narwhals are available to GF hunt in spring. Review of dates of spring hunted animals required.</i>
Smith Sound	GF Summer	Hard 0	by definition of summer aggregations
Smith Sound	GF Fall	Soft 0	low probability of availability, no tag data
Smith Sound	Upernavik (year round)	Hard 0	by definition of summer aggregations
Smith Sound	Uummannaq (November)	Hard 0	by definition of summer aggregations
Smith Sound	Disko Bay (winter)	Hard 0	unlikely movement
Smith Sound	CCA Spring	Hard 0	unlikely movement
Smith Sound	CCA Summer	Hard 0	by definition of summer aggregations
Smith Sound	CCA Fall	Hard 0	unlikely movement
Smith Sound	AB Spring	Hard 0	unlikely movement
Smith Sound	AB Summer	Hard 0	by definition of summer aggregations
Smith Sound	AB Fall	Hard 0	unlikely movement
Smith Sound	PI Spring	Hard 0	unlikely movement
Smith Sound	PI Summer	Hard 0	by definition of summer aggregations
Smith Sound	PI Fall	Hard 0	unlikely movement
Smith Sound	BIC Spring	Hard 0	unlikely movement
Smith Sound	BIC Summer	Hard 0	by definition of summer aggregations
Smith Sound	BIC Fall	Hard 0	unlikely movement
Smith Sound	BIS Spring	Hard 0	unlikely movement
Smith Sound	BIS Summer	Hard 0	by definition of summer aggregations
Smith Sound	BIS Fall	Hard 0	unlikely movement
Smith Sound	BIS Winter	Hard 0	unlikely movement
Somerset Island	Etah (Qaanaaq spring)	Hard 0	unlikely movement
Somerset Island	Qaanaaq	Hard 0	summer definition
Somerset Island	GF Spring	Soft 0	unlikely movement
Somerset Island	GF Summer	Hard 0	by definition of summer aggregation
Somerset Island	GF Fall	Hard 0	unlikely movement
Somerset Island	Upernavik	Hard 0	by definition of summer aggregations
Somerset Island	Uummannaq (fall)	Hard 1	tag data (one tag suggests connectivity) as indicative of behaviour
Somerset Island	Disko Bay	Soft 0	unlikely movement
Somerset Island	CCA Spring	Hard 1	likely migration pattern
Somerset Island	CCA Summer	Hard 1	by definition of summer aggregations
Somerset Island	CCA Fall	Hard 1	likely migration pattern
Somerset Island	AB Spring	Hard 1	observed migration pattern from tagged animals plus location of floe edge hunt
Somerset Island	AB Summer	Hard 0	by definition of summer aggregations
Somerset Island	AB Fall	Soft 0	observed migration pattern from tagged animals but unknown hunting location

Report of the Joint meeting of NAMMCO/JCNB

Stock	Site	Prop	Comment
Somerset Island	PI Spring	Hard 1	based on tags that show presumed migration behaviour and occurrence of floe edge hunt
Somerset Island	PI Summer	Hard 0	by definition of summer aggregations
Somerset Island	PI Fall	Soft 0	unlikely movement (no close by tagged data)
Somerset Island	BIC Spring	Soft 0	follow migration patterns follow similar patterns of animals moving into Baffin Bay (no tagged animals went there)
Somerset Island	BIC Summer	Hard 0	by definition of summer aggregations
Somerset Island	BIC Fall	Soft 0	likely migration pattern (tagged animals did not go there, 0/5)
Somerset Island	BIS Spring	Hard 0	likely migration pattern, no tagged animals went there
Somerset Island	BIS Summer	Hard 0	by definition of summer aggregations
Somerset Island	BIS Fall	0	tag data
Somerset Island	BIS Winter	0	tag data

ANNEX 3 – Report of the Survey Planning WG

Reykjavik, Iceland 14-15 April 2015

1. WELCOME

Chair Desportes welcomed the group and thanked Iceland for hosting the meeting. Desportes reviewed some of the major decisions from the meeting in October 2014, and at the SC meeting in November 2014. Among other decisions, it had been agreed that Iceland and Faroese would adopt a double platform configuration, with two independent and symmetrical platforms for the shipboard surveys (IO mode), surveying approximately the same area of the sea.

The Chair noted that the survey was less than two months ahead, as it was April 14th and the Icelandic vessels were starting surveying on June 9th and 10th. Many important things such as survey protocols and data collection systems (Faroese and Iceland) were not decided upon yet, and one vessel and some observers (Faroese) still needed to be chartered/hired. It was therefore necessary to be very practically oriented in order to complete the planning of the survey.

The Chair indicated that by end of the meeting a draft instead of a full meeting report would be agreed upon and that the full report will be submitted to the Participants for approval by e-mail by the week following the meeting.

Hammond commented that the surveys were not “coordinated” but rather a collection of associated national surveys. Desportes noted that this lower level of coordination compared to the 2007 survey reflected the choice made by the SC at the 2012 annual meeting.

It had however been agreed that the Icelandic and the Faroese ship-based surveys would be coordinated and follow the same basic procedures, thus allowing joined analyses. The aim of this meeting was to review the plan of the Icelandic aerial surveys and to facilitate the completion of the planning for the Icelandic-Faroese shipboard surveys. Norway and Greenland had not wished to participate, as their plans were largely set and on track since they will mostly follow previous survey protocols. Rikke Hansen did participate as an Invited Expert for aerial surveys, especially the associated equipment.

At the time of the meeting, it was unknown whether the NAMMCO proposal to the Norwegian Ministry of Foreign Affairs for the Extension surveys (which include the survey of the Jan Mayen area) would be funded. For the purpose of this meeting the group assumed that the Jan Mayen area would be surveyed either this year or by the Norwegian Institute of Marine Research in 2016 (as part of their normal mosaic surveys).

2. ADOPTION OF AGENDA

The agenda was adopted with minor revisions.

3. RAPPORTEURS

Prewitt was appointed as rapporteur with help from participants as needed.

4. RESOURCES PER AREA

4.1 Iceland

Iceland informed the group that the status of the funds available were the same as had been reported previously at the Scientific Committee and Council meetings, i.e., $\frac{3}{4}$ of requested funds were approved. The planned changes that are a result of the reduction in funds will be some reduction in effort, but also using mackerel and redfish survey vessels in addition to one dedicated survey vessel. Details on resources can be found in Table 1.

Report of the Survey Planning WG

Table 1. Resources available during the 2015 surveys. The survey areas are shown in Figure 1.

Countries	Vessel/ plane Platform eye-height (m)	Survey platform	Period	Nbr of Obs	Cruise Leader
Iceland	BS 15,5 / 10,5	Dedicated	09/06 – 02/07 (24 days)	7	T. Gunnlaugsson
			06/07 – 26/07 (21 days)	7	
	ÁF 18,6 / 15,3	Red fish/ cetacean Irminger Sea	10/06 – 30/06 (20 days)	6	G. Víkingsson
		Mackerel/ cetacean survey - IS	06/07 – 23/07 (18 days)	6	D. Gislason
		Mackerel/ cetacean survey - GR	24/07 – 10/08 (18 days)	4	
	Partenavia	Dedicated	20/06 – 17/07 (28 days)	3	D. Pike
Faroes	? ?	Dedicated	01/07 - ??? (about 5 weeks, 35 days)	8	B. Mikkelsen
Greenland	Twin Otter	Dedicated	04/08 – 19/08 (15 days)	4	R. Hansen
			20/08 – 24/09 (36 days)	4	
Norway	One vessel	Dedicated	Summer 2015		N. Øien

4.2 Faroes

The Faroes informed the group they will have one dedicated vessel, which has not yet been identified and chartered. Their plan was also to put observers on the mackerel survey, but there was likely not enough space on the vessel for marine mammal observers. Details on resources can be found in Table 1.

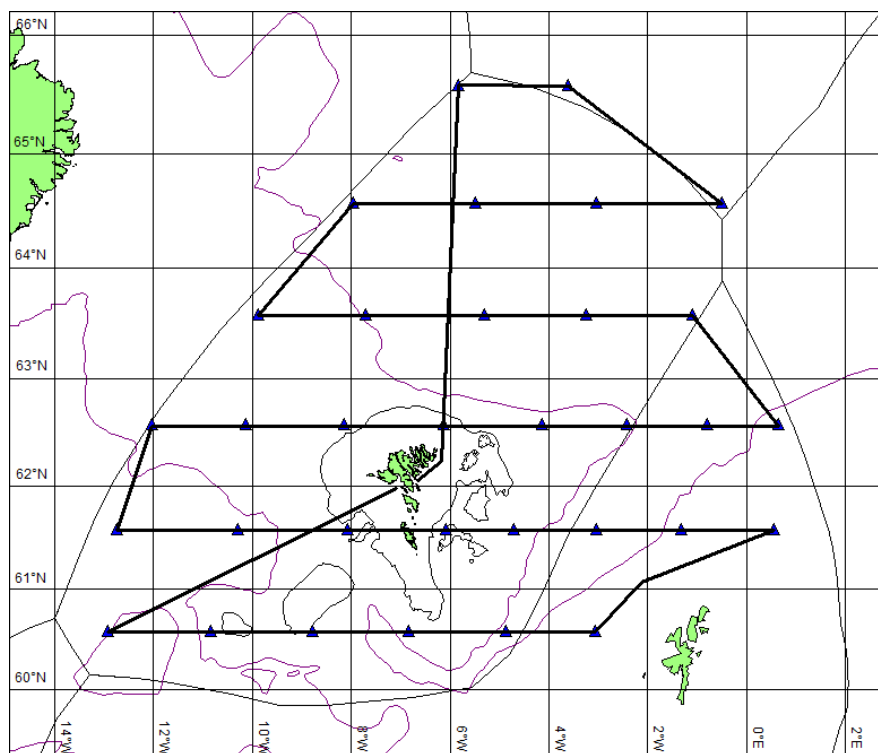


Figure 1. Map of mackerel survey around the Faroes. There will not be space on the vessel for marine mammal observers in 2015.

5. AERIAL SURVEYS

5.1 Survey methodology and protocols

5.1.1 Survey modes

Iceland will use the Partenavia airplane that has been used for previous surveys. The survey mode will be a partial double platform using cue counting. A video camera will be used with the intention of using it as an additional platform.

Pike presented SC/22/SPWG/05 which contained a survey plan and protocols.

5.1.2 Equipment

It was not clear at this point which data recording equipment would be used. The Redhen system was not developed as expected. See under 5.4.1.

5.1.3 Survey procedures

The survey procedure will be similar as in the past. Common minke whales are the target species for the aerial survey with cue counting as the primary method, and dive as cue. Data will be collected on all species encountered. The data will be collected in a manner to allow either cue counting or line transect analyses as appropriate.

The surveys will be carried out in independent mode, with two independent observers on the right side and one on the left side. The video camera might also be used as an independent platform. Further details can be found in the protocol document. However this document did not include details on the use of the camera since information about the camera was not available to Pike prior to the meeting.

5.1.4 Sighting protocol

The sighting protocol would be similar as in the past, with adjustment to the new recording equipment including the new digital inclinometer as is discussed below in Item 5.4.2.

5.1.5 Data collection procedures

Additional data that will be collected include Beaufort, glare, and sightability. These are collected whenever conditions change, or every 10 mins. Turbidity has not been collected routinely in the past because it is not often seen in Iceland, but it is noted when it is observed. Turbidity is also not much of an issue for common minke whales since the cue is a dive, but it could be an issue for other species.

5.2 Survey Design

5.2.1 Coordination with other surveys

There will be some coordination with the Greenlandic aerial survey on the new equipment and the subsequent changes in protocols.

5.2.2 Stratification

The stratification will be the same as in previous surveys.

5.2.3 Effort allocation by stratum

The effort allocation by stratum will be the same as in previous surveys.

5.2.4 Transect design

The zig-zag transect lines of the aerial survey had first been drawn in 1987 and the same lines had been used in all subsequent surveys. These lines do not derive from a formal design and thus cannot be guaranteed to provide equal coverage probability of each block. Equal-spaced parallel lines typically achieve equal coverage probability whatever the shape of survey blocks but zig-zag lines are unlikely to achieve this except for approximately rectangular shaped blocks. The inner survey blocks have highly irregular boundaries at the coast and the possibility of improving the design by using equal-spaced parallel lines was discussed.

One potential disadvantage of parallel lines is the time spent off effort flying from the end of one line to the beginning of the next. However, this time is typically used for observers to get a few minutes rest from searching so is not wasted unless the distance between lines is large. In the Icelandic survey, the lines in the inner blocks are closely spaced so flying between the ends of parallel lines would not waste time.

Program DISTANCE provides an easy and effective way to assess how well a survey design achieves equal coverage probability through simulation and, therefore, to choose the most appropriate design. The SPWG **agreed** that Pike would explore equal-spaced parallel line and equal-spaced zig-zag line survey designs for the inner blocks (numbers 1, 2, 4, 6, 8) to determine which design best achieved equal coverage probability. Program DISTANCE then generates a random realisation of the chosen design and produces a file of transect waypoints.

The outer survey blocks (3, 5, 7, 9) are approximately rectangular and it was agreed that the zig-zag lines provided more or less equal coverage probability and should remain the same as previous years. Replacing these wide-angle zig-zag lines with equal-spaced parallel lines would unnecessarily increase the amount of time flown between transects.

These new designs will be generated by Pike and then Iceland will decide on the best survey design.

5.2.5 Rules for adaptation

Generally the survey will be flown as designed. However, if time is running short and the opportunity arises to partially complete a stratum, a portion of the planned effort may be flown by skipping lines or be transecting between every second endpoint in strata covered by zig-zags.

If the plane encounters pack ice while on a track line survey should keep going as planned.

Occasionally very large groups of pilot whales, humpback whales or dolphins are encountered. At the discretion of the cruise leader, these will be closed upon after visual observations are completed, and flown in an adaptive video strip survey to provide a complete count.

5.3 Platform

As mentioned above, the same Partenavia plane will be used this year as in the previous surveys.

5.4 Equipment and software

The plan is to incorporate HD video to function as an independent platform. The camera will be pointed at an oblique angle on the right side to provide resighting data for the two observers on that side, and the observers will be rotated on a daily basis. The group noted that it will be important to make sure there is some overlap of what the front observer can see and what the camera will see.

Iceland noted that they will use the camera that comes with the Redhen system (same camera as Greenland).

5.4.1 Redhen update

On Monday 13 April Hansen provided an update and training session with the Redhen system. Unfortunately the equipment provided did not provide 4 separate recording channels as had been requested, making it unusable for recording observer audio. The hope is that this can be resolved in time for the surveys. If not, Greenland plans to test their old audio recording system with the new Redhen VMS (Video Mapping System). If this does not work, they may have to use Dictaphones for audio recording.

Iceland will investigate other audio recording systems, including, potentially, the systems used by SCANS and another system using android phones or tablets.

5.4.2 Inclinator/angle measurement device

NAMMCO funds were used to develop a prototype of a new device to electronically measure and log angles. Gunnlaugsson worked with a company in Iceland, Pi Engineering Service (*Pi Verkfræðihjónusta ehf.*) who presented the prototype to a subset of the group the day before the main meeting. The group agreed that the technical aspects of the device were impressive. The group thanked Gunnlaugsson for his efforts on developing this new piece of equipment, which represented a major step in technical development. The group recommended that a technical paper be developed describing the new device once the testing has been completed. Another idea is that this could be presented at the Society for Marine Mammalogy meeting in December 2015.

The group noted that the ergonomics of the device would need to be adjusted to fit the logistics of aerial surveys. Baldur Thorgilsson from Pi Engineering Service will modify the shape based on input from Pike and Hansen. Pike will develop some testing procedures and modify the protocol to include the new features of the digital inclinometer. For example, it should not be necessary to wait until the animal is abeam to take the angle of the sighting, since the angle can be measured as soon as the animal is sighted. In addition, it would be easier to get more angle measurements on large groups of animals since it is very quick. It will make it also easier to record accurate angles to every cue.

5.5 Survey leaders and Observers

5.5.1 Hiring of observers and crew leader

The two observers have been hired. The crew leader will be Dan Pike.

The group discussed that it could be a good idea to have a “backup” observer or two who could be available on short notice in case one of the observers is not able to continue. Having backup observers already identified is also particularly important because Vikingsson and Gunnlaugsson will be on board the vessel surveys for a large part of the time during the aerial surveys, and therefore may be unavailable to assist with crew logistics. A couple of possibilities for backup observers could include someone from the Secretariat (Prewitt), Rikke Hansen from GINR, or Hansen could provide a few names of observers Greenland have used.

5.5.2 Training

The plan is to have some classroom time, some ground training in the plane, and to do 1-2 test flights. Iceland will have access to the plane for about 3 days before the start of the survey (20 June) for ground training.

It has become nearly impossible to find accommodations at short notice in Iceland during the summer, which

is an issue for the aerial survey because the location of the operational base is weather dependent. Therefore, it will be necessary to make arrangements in advance for short-notice accommodations for 3 people in Reykjavik, and 4 in Akureyri, Egilstadir and possibly Isifjorthur. MRI agreed to make these arrangements.

6. VESSEL BASED SURVEYS

6.1 Update from testing of new procedures

6.1.1 Drones

Mikkelsen informed the group that a drone was purchased with NAMMCO funds in December 2014, but has not been tested yet. There is a person in the Faroes with drone experience and Mikkelsen will coordinate testing out flying the drone with this person. If it appears to work well, the Faroes will buy another drone to have a spare on the boat.

Protocols for testing and use during the survey were not available at the meeting. Mikkelsen plans to begin testing by flying the drone on land, and then bringing it out on the sea. Mikkelsen noted that others have told him that it can be quite difficult to fly drones over the sea. Ideally some test flights would be done if there is a drive hunt.

The battery life of the drone is about 15 minutes. The transect is designed on a mobile phone and then it flies on its own. When the drone is flying, the vessel will need to stop. The drone will have an HD camera with a polarised filter that will collect video of pilot whale groups to help estimate group size.

The protocol for when to deploy the drone will need to be defined. Drone pilot/cruise leader will decide when to launch the drone.

6.1.2 Helikites

Mikkelsen has been in contact with the manufacturer, but the helikite has not been purchased yet. The group discussed whether video or still images would be collected and noted that video is easier for people watching to see animals, and either one takes lots of time for post-processing.

The group concluded that there is not enough time until the survey at this point, and there is a concern that the other survey components should not be jeopardised by spending time on developing the helikite.

6.1.3 Pilot whale satellite tagging

The Faroes have satellite tags and have also ordered some limpet tags. However there has not been any tagging since 2012.

It was previously discussed that tagging information could be used to define survey areas and strata, using “home range” information for intensifying survey coverage in some areas/blocks. Hammond noted that caution should be exercised in allocating different coverage intensities to small blocks because this precluded pooling data across blocks for estimation of encounter rate should the number of sightings in some blocks be very small.

The group decided to define the survey boundaries based on the knowledge that is available now, rather than trying to use satellite tracks.

6.2 Survey methodology and protocols

6.2.1 Survey modes

At the meeting in October 2014, the group agreed that both Iceland and the Faroes would use double platform, IO method, where two independent and symmetrical platforms survey the same body of water (some difference in area will arise from the difference in height of the platforms). The method does not assume that the probability of detecting an animal on the trackline is one. The two platforms act as two (independent) primary platforms, both providing a sighting rate. There will be six to seven observers per vessel, each of whom will be assigned to one platform for the whole survey.

For common minke whale sightings, it will be very important to record the cue to have the possibility to analyse the data in the same manner as the Norwegian surveys.

Communication between observers and the bridge is necessary, and technicians from MRI are ensuring this.

The shipboard surveys will be conducted in passing mode for the Icelandic and Faroese dedicated vessels, with the possibility of delayed closing for checking species identification and school size. Requests to close on sightings should follow rules outlined in the survey protocol and the final decision will be taken by the officer in the bridge based on information received from the two independent platforms.

Sighting forms will be developed by Gunnlaugsson and sent to the Faroes for comments. It is useful to restrict the Excel cells so that observers can only type in the specified codes (i.e., the cell does not allow observers to type something that does not exist).

6.2.2 Equipment

Recording equipment for the vessels had not been decided upon at the time of the meeting.

Iceland informed the group that Thorvaldur will obtain binoculars with reticles (and preferably without a compass). If only find binoculars with reticles and a compass are available, they will have to use those.

The equipment needs to be decided upon soon, and Gunnlaugsson and Mikkelsen need to liaise on this in the next weeks. This is also necessary to complete the survey protocol.

6.2.2.1 Angle boards

Mikkelsen is looking into developing a new device to measure angles. Plan B will be to use the angle boards. If angle boards are used, each observer should have their own (not a centralized angle board).

6.2.3 Survey procedures

6.2.3.1 Vessel

Sighting protocol

On both platforms, two observers will be searching at any one time, one observer by naked eye and the other one using binoculars with reticles. Search methods will rotate between observers. The search pattern is as follows:

The observer searching with naked eyes will scan the sea from 90 to 90, though concentrating his search from 70° to 70° from the ship to approximately 1000 metres. This observer will estimate the radial distance to the sighting using the distance stick or using the reticles on the binoculars.

The other observer will search with 7X50 binoculars, concentrating within 30° port to 30° starboard and concentrating beyond 500m. This observer will estimate radial distances using the reticles.

Large Groups

The Faroes plan to use the method used in previous surveys, where sightings of large groups are split into subgroups, and subgroup size and the angle and radial distance to the centre of each subgroup were recorded. Distance between 2 groups is defined by a number of body lengths, with a group containing individuals not more than 2-3 animal lengths from each other.

Data collection procedures

Procedures for all initial sightings of any cetacean species are similar, but the following resighting procedures vary somewhat according to the species sighted. Only common minke whales should be tracked, i.e. every resighting recorded, until the sighting comes abeam and record time, angle and distance for each surfacing. Specific protocols are described in the sighting protocols.

Once a group is abeam, if the species or the group size has not been identified with confidence, then the vessel may go off effort and close on the group. The upper platform will decide whether to close on a group. This procedure will be limited to sightings within 1 km of the trackline at the time of the closing and to unidentified baleen whale for species identification and to common minke, fin and pilot whales for school size estimation.

Ice edge protocol

The northern Iceland dedicated vessel could encounter ice. If the ice edge is not encountered where planned the IWC-SOWER protocol (guidelines 2006-7) should be followed.

Ice edge waypoints are established 2.5 nautical miles from the planned ice edge. If the ice edge is encountered prior to reaching a planned waypoint, 2.5 nautical miles from the estimated ice edge, the vessel shall follow the ice edge, off-effort, until the survey can be resumed on the planned trackline. If the ice edge is not encountered on reaching a planned ice edge waypoint, research shall be conducted on a bisector (on effort), until 2.5 nautical miles from the true ice edge. Returning to the planned way point is done on effort as well. If the constructed cruise track intersects a peninsula of pack ice, the vessel will steam around the peninsula until effort can be resumed on the constructed trackline.

The exact position of the ice edge should be recorded or estimated as accurately as possible close to and of both sides of the point of encounter, so the actual/true shape and size of the strata area can be approximated.

Group size estimation

A group can be thought of as the smallest unit that could be “tracked”. A convenient rule is to define a group as containing individuals not more than 2-3 animal lengths from each other. The group may be exhibiting the same swimming pattern and/or general behaviour such as travelling, milling or resting, although not necessarily with a synchronised surfacing pattern. The distance and angle measurement should always be estimated to the geometric centre of the group.

Difficulties arise when groups are not distributed in tight, easily defined clusters, but in loose aggregations whose boundaries, and size, must be determined subjectively. It is better to identify, smaller, homogeneous groups (sub-groups) within the aggregation, each associated with a separate distance, angle and group size estimate.

Calibration experiments

It will not be possible to perform distance experiments on the mackerel surveys, so the observers will have to train when the vessel is travelling. The group did not think that it was necessary for the dedicated vessels to conduct distance and angle experiments, as this information has not been used in the analysis.

The IWC RMP requirements and guidelines for conducting surveys (IWC 2012) state:

“Subjective estimation by eye of distance to sighted groups may be used provided that adequately documented experiments are conducted on each vessel to enable corroboration or calibration of the distance estimates... Angle and distance experiments should be carried out, if possible, before, during and after the survey. Methods that allow accurate determination of the angles and distances to the target objects, simultaneously with the estimated angles and distances, should be implemented.”

Data validation

It was underlined that validation of the data should ideally be done the same day. Missing data should be completed by going back to the audio recordings. However, as the recorded procedures were not yet defined it was not possible to establish the validation procedures at this point.

6.2.3.2 Drones

Sighting protocol

Data collection procedures

Calibration experiments

No protocol or procedures have been developed as the drone has not yet been tested; there was no further discussion on this subject (see under 6.1.1).

6.3 Survey Design

6.3.1 Coordination with other surveys

The survey design updated at this meeting was developed assuming that the Jan Mayen area will be surveyed either this year (with funds from the Norwegian Ministry of Foreign Affairs) or by the Norwegian Institute of Marine Research in 2016 (as part of their normal mosaic surveys).

The design of the survey was made taking into account a probable SCANS-III survey that will survey an area with a northern boundary of 62°N, which is the southern boundary of the Norwegian surveys, and otherwise extent as far west as 200nm from the coast of UK and Ireland.

6.3.2 Survey boundaries and stratification

Survey boundaries decided upon at this meeting are given in Figure 1. Table 2 shows the surface area of the planned survey blocks.

If East Greenland is not surveyed then the Icelandic dedicated survey boundary will be expanded towards to coast.

6.2.1 Effort allocation by stratum

For fin whales, the Irminger Sea is a critical area where there were many sightings in 2007. Currently it will be partly covered by the Icelandic redfish survey and the Russian redfish survey. Effort will be allocated from the dedicated Icelandic survey to this area to guarantee good and continuous coverage. There is also a possibility that the Russian redfish survey may be able to follow the same observation protocols as Iceland (double platform, IO, etc.).

Given the importance of specific areas, the group discussed how to allocate effort to the blocks shown in Figure 1 and decided that the average realised effort from previous surveys (Table 3, below) should be used to estimate how much actual effort was likely to be available during the 2015 surveys.

Equal effort/intensity will be applied in the Faroes areas.

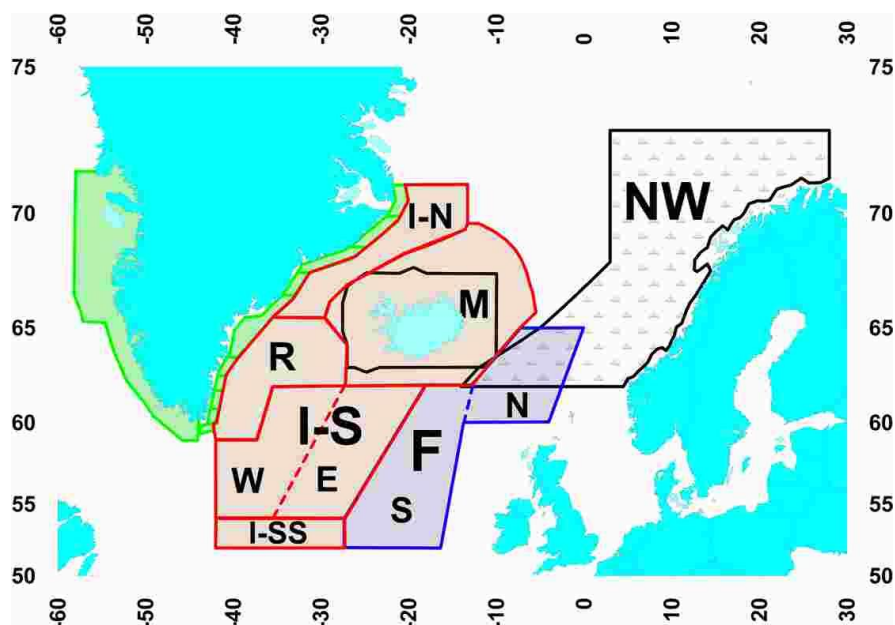


Figure 1. Map (Mercator projection) of the planned survey areas for 2015. NW=Norwegian surveys, F=Faroes (N=North block, S=South block), I-N=Iceland North block, I-S=Iceland South block, I-SS=Iceland South sub-block, R=Redfish surveys, M=Mackerel surveys. Green areas show Greenlandic aerial survey areas.

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Table 2. Surface area of the survey blocks shown in Figure 1. The CM area (in italics) is not included in the total area calculation. The CM and I-Air blocks are not shown on Figure 1.

Block	Sub-Block	Area (nm²)
<i>CM (2016)</i>		<i>301,033</i>
I-S	W	164,334
	E	175,246
	Sub-TOTAL	339,580
I-SS		87,066
I-N		62,695
I-R		120,524
I-M		212,384
I-AIR		85,546
F	N	102,201
	S	245,471
	Sub-TOTAL	915,887
GE		37,685
GW		47,691
	TOTAL	85,376
NW		333,877
GRAND TOTAL		1,674,720

Table 3. Effort for cetacean surveys in Iceland and the Faroe Islands, 1987-2007. Only full observation effort in Beaufort 0-5 included.

Year	Vessel	Area	Speed (Avg on full effort)	Days at sea	Full effort/day, incl. transit (nm)	Full effort: redfish research survey (nm)
2007	AF2	Irminger Sea	10.9	30	56.5	60
2007	JB	South Iceland	9.4	26	89.7	
2007	VE	North Iceland	9.8	23	37.6	
2007	FI	South of Iceland/Faroes	8.9	24	62.6	
2001	AF2	W and SW Iceland	11	22	82.4	96.3
2001	BS	W and SW Iceland	10.6	22	79.4	91.6
2001	AF1	N/NE Iceland (Jan Mayen)	9.2	35	97.3	
2001	FI	Scottish S coast/Faroes/SE Iceland	9.5	27	91.9	
1995	AF2	Irminger Sea	9.1	30	65	
1995	ST	Irminger Sea	9.4	41	62.7	
1995	FI	Around Faroes	8.8	30	55.7	
1989	AF2	South Iceland	8.6	35	75.1	
1989	SK	South Iceland	9.6	34	69.1	
1989	H9	East Greenland/South Iceland	8.9	18	87.5	
1989	H8	East Greenland/South Iceland	9.2	18	96.2	
1989	FI	Area around SE Iceland/W Ireland	11.1	25	59.6	
1987	AF1	North part Irminger Sea/Jan Mayen	9.8	34	104.7	
1987	KE	South Irminger Sea	9.3	34	117	
1987	SK	West Iceland to East Greenland	9.9	34	98.3	
1987	FI	N and S of Faroes/S Norway	9.6	56	97.7	

6.2.2 Transect design

A double set of transects will be designed for each stratum. Pike will design the transects for the Faroes vessel survey, and the Icelandic aerial and vessel surveys.

6.2.3 Rules for adaptation

For the dedicated surveys (i.e., not the fisheries surveys), the design will be fixed before the survey, and surveying at the ice edge is the only time when a survey transect line may be adapted. If the ice edge is not where expected, the adaptation should occur according to the standard IWC-SOWER protocol (see under point 6.2.3.1.3).

6.3 Platform(s)

It is important to ensure that the observation platforms are isolated acoustically and visually to maintain independence between the observers.

The Icelandic platforms are available and will be put on the vessels in the weeks/days before the survey.

The Faroes have the platforms that were used on previous surveys and will install them on the vessel in the days before the survey.

6.4 Cruise leaders and observers

6.4.1 Personnel

The cruise leaders on the dedicated Icelandic vessels will be Thorvaldur Gunnlaugsson and Gisli Vikingsson. The cruise leader on the mackerel survey will be Davið Gíslason. The observers have all been hired, and there will be about 2/3 experienced observers and 1/3 inexperienced.

For the Faroes survey, Mikkelsen will be the cruise leader, and the plan is to have 5 experienced observer (2 have been hired), and 3 inexperienced observers (all 3 of which have been hired). The remaining 3 experienced observers will be hired as soon as possible.

6.4.2 Training

The Faroes plan to bring observers in a few days before the survey and have a meeting to go through the protocols. The observers will also be used to help prepare the ship, and then the first hours or days of the ship time will be used for training.

Iceland's training plan is similar to Faroes' plan described above, with a meeting with all observers prior to the vessel leaving, and then training on the transit out to the survey area. Iceland will have the vessel 2-3 days prior to the dedicated survey area so there will be time for training with equipment (e.g., in the harbour).

7. COLLECTION OF ANCILLARY DATA

Iceland

Mackerel surveys will collect hydrographical data, acoustic monitoring of fish and krill. It was noted that there may be data for krill in the old survey files as well that can be used for comparison.

The dedicated Icelandic vessel will collect SST. For the aerial survey, Pike will investigate whether the SST measuring equipment that was used in Canada is available for this survey, and also whether it would fit in the port with the camera.

Faroes

No plans to collect any ancillary data.

8. ACOUSTIC SURVEY

Iceland have no plans to collect acoustic data. In TNASS-2007, the data yielded very few detections. Vessel noise was the likely problem last time and this year they will be using the same vessel.

The Faroes still have the equipment that was used during TNASS-2007. Doug Gillespie from SMRU is willing to help set it up for this year's survey. However the vessel noise must be measured once the vessel is known or it is pointless to deploy the equipment.

9. BIOPSY AND TAGGING STUDIES

The Faroes plans to deploy 7 satellite tags during the survey.

Iceland noted that they need samples from East Greenland, but after discussion within their group, and in consultation with Mads Peter Heide-Jørgensen, they decided that it would take too much time on the big survey vessel. It will be much easier to do this from the coast on a smaller boat.

10. BIRD SURVEY

Faroese have no plans to have bird observers.

Iceland noted that they have room for bird observers on their dedicated survey vessel. They have invited the bird researchers but have not yet had a response.

11. CONTACT AND COORDINATION DURING MAIN SURVEY

The group noted that the survey boundaries will not change even if something goes wrong with a vessel. The southernmost block of the Icelandic dedicated survey could be completed by either the Faroese or Iceland, so communication must be maintained during the survey.

The Secretariat is interested in getting updates.... noted that if vessels/observers send updates/pictures/stories etc. to the Secretariat, we will post them (NAMMCO website, Facebook, etc.).

12. COORDINATION WITH OTHER SURVEYS

The Faroe Islands will coordinate their survey areas with the probable SCANS-III survey.

13. STRATEGY FOR DISSEMINATION TO THE WIDER PUBLIC AND PRESS

As noted above, the Secretariat will post on the website if we receive information vessels.

14. TASKS TO BE COMPLETED

Aerial

- MRI agreed to make housing arrangements for the crew leader and observers- **Vikingsson**
- Investigate options for recording equipment- **Hansen/Pike**
- Protocols- **Pike** will update with recording equipment and digital inclinometer
- Purchase high capacity hard drives for backing up data (aerial), phones + spare- **Gunnlaugsson**
- Redesign- **Pike**
- Camera purchase (need 1 week)
- Purchase recording equipment
- Camera mount- **Gunnlaugsson** will coordinate with pilot
- **Pike** will make sure observers have protocols
- **Pike** will investigate the SST device used by the Canadian surveys

Vessel

- **Gunnlaugsson** will give **Pike** the effort data from the previous surveys to use as the estimated effort that will be available for this survey (Friday 17 April 2015)
- Faroese needs to charter a vessel- **Mikkelsen** (2 weeks)
- Faroese observers hired- **Mikkelsen** (2 weeks)
- Drone testing and Protocol- **Mikkelsen**
- Weather and effort recording software- **Mikkelsen**
- Recording equipment-**Gunnlaugsson/Vikingsson/Mikkelsen** (April)
- Vessel protocols (2 weeks)- **Gunnlaugsson/Vikingsson/Mikkelsen/Desportes**. When finalised, these will be sent to Debi Palka because she is very experienced with IO surveying.
- Crib sheets (list of codes, data to record, etc.)- **Mikkelsen**. Will be sent to Iceland to print and laminate
- High capacity hard drives for backing up data, phones (if used) + spares- **Vikingsson**
- Equipment list for vessels- **Vikingsson**

15. DATA VALIDATION AND ANALYSIS (POST SURVEY)

- Gunnlaugsson will validate the data from Iceland and the Faroes before it is given to Pike for analysis.
- The current plan for the Iceland aerial survey data is to contract Pike to do the analysis.
- The Faroes data will need to be analysed separately from the SCANS-III data since Faroes are using IO and SCANS-III will use tracker method. Pike will likely be contracted to analyse the Faroese data.
- The SPWG noted that there are also still papers from the TNASS-2007 survey that need to be published. The pilot whale trend paper is nearly completed, and the group discussed whether to finalise the paper, or wait until the 2015 data is analysed. It was decided that it would be best to wait for the 2015 data and include that in the paper.
- The plan for the large baleen whale data is to analyse the Icelandic and Faroese data together.
- The group noted that papers from the NASS2015 surveys could be written up in the form of papers to be published, rather than working papers. There is the possibility to publish old TNASS-2007 and NASS2015 papers together in a themed volume of the *NAMMCO Scientific Publications*.

16. OTHER ITEMS

The Chair reminded the SPWG that there is now less than 8 weeks to the start of the survey (in Iceland) and action should be taken.

17. NEXT MEETING

A post-survey debrief meeting will be held in conjunction with the SC meeting (1 day early), week 46 (9-13 November) in the Faroe Islands.

18. ADOPTION OF REPORT

The Chair thanked all of the participants, and in particular the Invited Experts Hammond, Hansen, and Pike for their efforts. The participants thanked the Scientific Secretary for her hard work, and all thanked the Chair for a well-run and productive meeting.

A draft version of the report was adopted during the meeting and was finalised via correspondence on 30 April 2015.

REFERENCE

International Whaling Commission (2012) Requirements and Guidelines for Conducting Surveys and Analysing Data within the Revised Management Scheme. *J. Cetacean Res. Manage.* 13 (suppl.):507-518

Addendum to Survey Planning WG meeting (30 April 2015)

Based on the information available during the meeting, the SPWG assumed that the East Greenland aerial survey would occur in 2015, and survey boundaries were developed based on this information. As of 30 April 2015, NAMMCO still has not received an answer on our proposal to the Norwegian Foreign Ministry for NASS2015 funding. When the Secretariat inquired whether the logistics could still be arranged for surveying the Jan Mayen area even with such late notice, Øien confirmed that it was too late to arrange for surveying Jan Mayen. The NASS2015 Steering Committee met via Skype on 27 April 2015 and prepared an answer to a request from the FAC for an update on the situation (see below). The main discussions of the StC meeting was that the Norwegians will not survey the Jan Mayen area in 2015, and therefore Greenland has now decided to apply the funds from the East Greenland survey towards the West Greenland surveys, which have more management implications for Greenland. This will leave much of the coastal East Greenland area unsurveyed, as the Icelandic vessel survey area can be modified in the northern block to fill in where the East Greenlandic aerial survey may have occurred, but this is not possible in the southern part which is covered by the redfish surveys.

ANNEX 4 - Post-cruise report of the NASS2015 Steering Committee

Extension surveys conducted as part of the national cetacean surveys in the North Atlantic in 2015.

Funding for the planned extensions of the national survey effort, as a continuation of the North Atlantic Sighting Surveys (NASS), was available in June 2015. The late approval of the funding complicated the logistical arrangements for the survey somewhat; however, with the exception of a two-week delay of the aerial survey in East Greenland, all parts of the extension surveys were accomplished.

Originally the survey was planned as a Trans-Atlantic Survey but the lack of participation from Canada and the US made the survey similar in coverage and range to the previous NASS surveys.

INTENSIFIED SURVEY EFFORT AROUND THE FAROE ISLES TARGETING PILOT WHALES

The Faroese participation in NASS 2015 was to cover basically the Faroese EEZ as well as an area south of the Faroese waters, south to 52°N, between UK EEZ and 21°W (Fig. 1). The waters to the west were surveyed by Iceland; and the plan is for UK to survey the waters to the east, the UK EEZ, in 2016.

The survey methodology was Independent Observer mode, with two parallel two-way independent platforms. Duplicate identification was to be done post survey. Target species was the pilot whale. Transects were designed by Daniel Pike, with a total planned effort of 3200 nm. The 65 m. long fishing vessel “Høgiklettur” was rented for 35 days. Eight observers, operating in two teams of four observers each, were contracted. Five of the observers had previous experience with whale surveys, while three observers had basically no experience. Three observers were on effort on each platform at any time, one searching the transect line with 7x50 binocular, out to 30°, while the naked eye observers were covering each side of the transect line, out to 45°. The working schedule was a 30 min. rotation between the three positions on the platform, and 30 min. off, from 06 to 22, with 1/2h meal breaks at 12.30 and 18.30.

Effort data was registered in the software Logger 2010, running on a laptop, connected to a GPS antenna, for precise time and position logging. The computer was located on the right platform, and the observer located at the computer, was entering the effort data. Sightings were entered on paper forms, each observer responsible for own registrations. But observers helped each other for data recording, especially the 7x50 observer with precise time stamp and angle recording (distance was made with reticule readings). For distance estimation, each observer used a measure stick. A central time display was located on each platform, synchronized with the GPS time. Observers were responsible for validation and backup of own data in the end of each day.

Realized effort was approximately 2900 nm, or around 90% of planned effort. 65% of effort was covered in Beaufort 3 or less, 25% in Beaufort 4 and 10% of the effort was sailed in Beaufort 5. 16 cetacean species were observed during the survey. The sighting data is not been processed yet.

For more precise estimation of pilot whale group size, the idea was to use a drone to film compact groups from above, and compare with the group size estimates by the observers. During the survey, it was possible to film around eight individual groups by the drone. These data have not been analysed yet. The plan was also to tag some individuals from groups of pilot whales, with satellite transmitters, in order to follow the movements and distribution in the period during and after the survey. The combination of pilot whales presence and good weather was uncommon, and only one attempt was made to approach pilot whales from an inflatable. The whales avoided the boat, and it was not possible to come sufficiently close to the whales to deploy the tags.

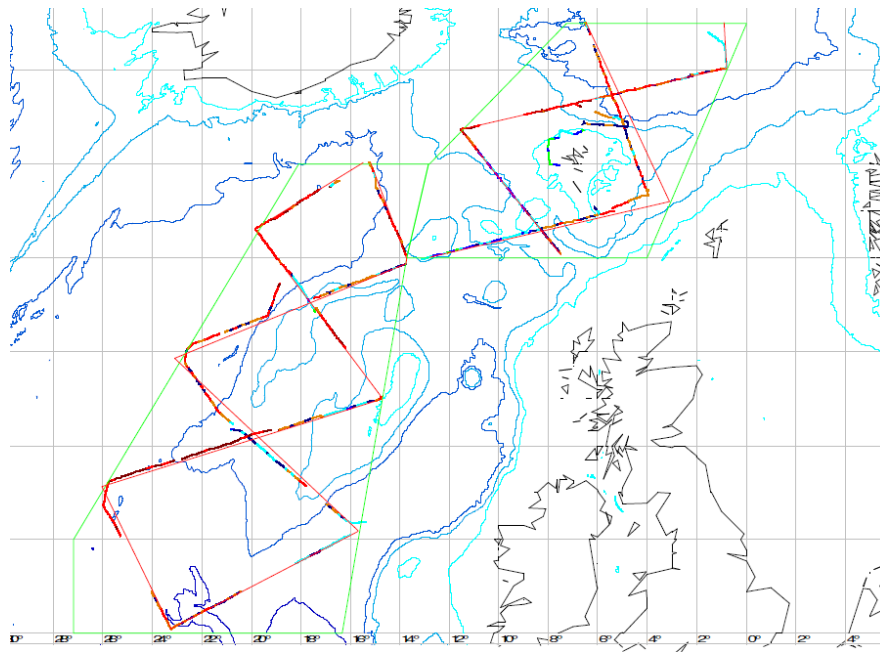


Figure 1. Transect line covered by the Faroese ship-based survey effort in 2014.

SURVEYS OF EAST AND WEST GREENLAND

Aerial surveys of East and West Greenland were conducted between 15 August and 1 October 2015. The East Greenland coastal area was covered between 18 August and 27 August after initial observer training off the coast between Eyiafjörður and Skjálfandi Bay on 17 August. The survey platform was a high-winged twin engine DeHavilland Twin Otter chartered from Norlandair and equipped with four bubble windows and a long range fuel tank. Observations were made independently from a front and a rear platform with a total of four observers. The observers were instructed to record data on time at first detection, angle abeam measured with Suuno inclinometers, group size and species. Recording of observations was done on Sony Dictaphones and on a specially developed recording system for aerial surveys developed by Remote Geo (3307 South College Ave. Fort Collins, Colorado) that included high definition video monitoring of the trackline with georeferenced GPS track and individual observer recordings.

Weather conditions were favourable during the survey of East Greenland however in West Greenland the alternating fog and wind provided limited windows with acceptable survey conditions with sea states less than 4. Parts of the northern area in West Greenland planned to be included in the survey could not be covered due to inclement weather conditions.

The total survey effort under acceptable conditions included 4,064 km in East Greenland and 9,235 km in West Greenland. The distribution of realized survey effort under acceptable conditions is shown in Fig. 2.

The total number of sightings was 564 and the distribution on species and East and West Greenland are indicated in Table 1.

The analyses of the survey results will include corrections for perception bias estimated from the double observer trials and availability bias will be addressed by telemetry studies of the time the animals are available to be detected at the surface. Data from telemetry studies are available for minke whales, humpback whales and harbour porpoises.

Table 1. Distribution of sightings and areas for the aerial surveys in East and West Greenland. The sightings include unique sightings seen by either the front or rear survey platforms.

Sightings	Right side of plane		Left side of plane		Both sides of plane		TOTAL
	East Greenland	West Greenland	East Greenland	West Greenland	East Greenland	West Greenland	
Minke whale	11	12	8	9	19	21	40
Fin whale	59	20	58	12	117	32	149
Humpback whale	34	11	45	8	79	19	98
Blue whale	0	0	1	0	1	0	1
Sei whale	0	1	0	0	0	1	1
Sperm whale	3	4	0	1	3	5	8
Bottlenose whale	0	5	0	8	0	13	13
Killer whale	2	1	2	0	4	1	5
Long-finned pilot whale	4	22	0	18	4	40	44
White-beaked dolphin	9	14	13	14	22	28	50
Harbour porpoise	2	44	0	11	2	55	57
Unidentified small whale	2	2	0	0	2	2	4
Unidentified medium whale	1	1	0	0	1	1	2
Unidentified large whale	26	3	30	4	56	7	63
Footprint	7	3	7	12	14	15	29
Sum							564

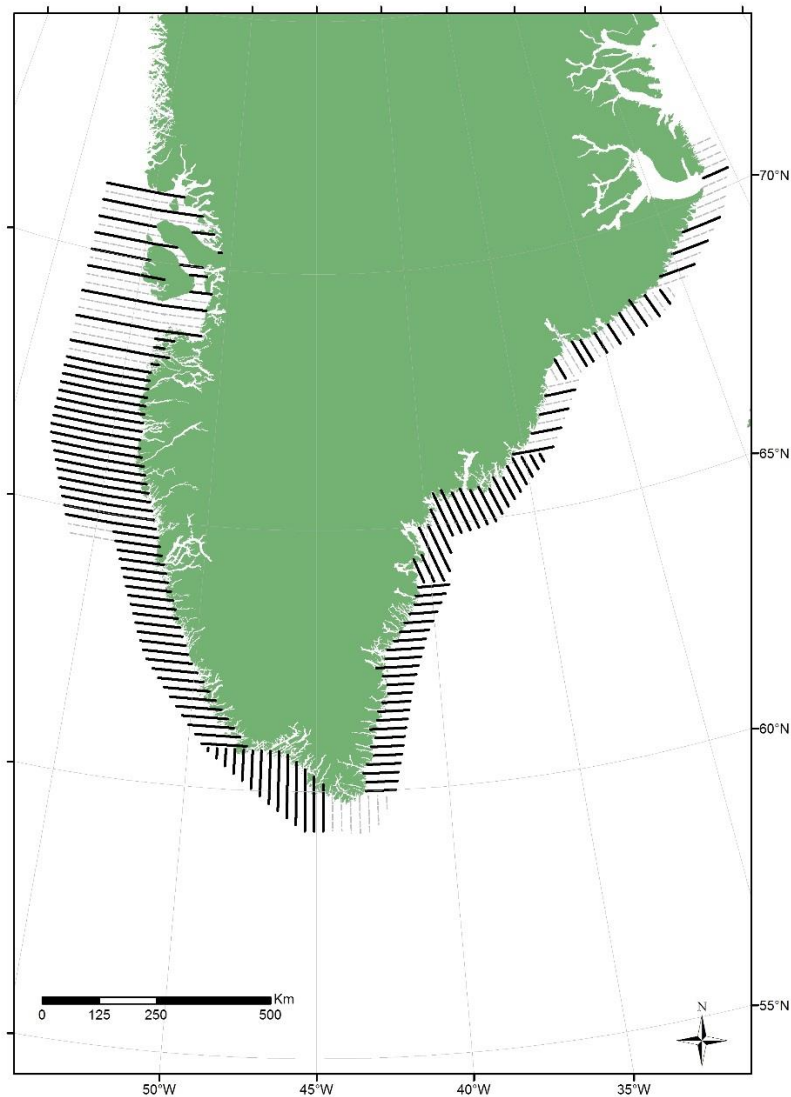


Figure 2. Map of realized (black) versus planned (grey) survey effort in sea state <5.

SURVEYS OF THE JAN MAYEN AREA AND THE NORWEGIAN SEA

The surveys were conducted from the M/S Fisktrans (57.3m) over the period 22 June to 30 August 2015 with a double platform design, based on the methods adopted for the Norwegian national surveys with minke whales as the target species. The surveys involves two independent symmetrical platforms and tracking of minke whales. It was divided into three survey periods and finally the last week was dedicated to sampling of biopsies and photo ID. The first and third survey period was conducted within the originally planned EW are (coastal and eastern Norwegian Sea), while the second period (13 July to 2 August 2015) was dedicated to the Jan Mayen area.

In the Norwegian Sea (EW) about 55 % of the planned transect was covered in primary search mode (Fig. 3). The coverage seems to be about as in 2011 for the Norwegian Sea. For Jan Mayen numbers are not yet available, but apparently also there about 50 % of the planned transects were covered in primary search mode.

The number of sightings of groups are distributed by species and area are shown in Table 2. For the Norwegian Sea the total impression was that there were few sightings and many of them in the northeast, off North Norway. There were few minke whale sightings, and these were thinly distributed over the area but none were seen in coastal areas south of Vestfjorden. Fin whale sightings were made off North Norway, and there were perhaps more fin whale sightings in this area than in earlier surveys.

For the Jan Mayen area, the initial impression is that relatively few baleen whales were seen and minke whales were mainly seen in the northeastern part of CM3.

Table 2. Preliminary summary of sightings 2015. Number of groups of whales seen from the upper and lower platforms during primary search by survey stratum, during the 2015 survey. The ‘F’ effort is conducted in conditions outside the boundaries defined for the primary ‘T’ effort, and observations during ‘F’ effort are given in parentheses.

Species	Platform	Survey block					Total
		EW1	EW2	EW3	CM1a	CM3	
<i>Minke whale</i>	<i>Upper</i>	8	11	11	4	25	59
	<i>Lower</i>	9	10 (+1)	13	3	26 (+3)	61 (+4)
<i>Fin whale</i>	<i>Upper</i>	46	2	0	1	6	55
	<i>Lower</i>	35	1	0	0	4	40
<i>Blue whale</i>	<i>Upper</i>	0	0	0	0	2	2
	<i>Lower</i>	0	0	0	0	1	1
<i>Humpback whale</i>	<i>Upper</i>	10	3	0	0	1	14
	<i>Lower</i>	4	3	0	0	2	9
<i>Harbour porpoise</i>	<i>Upper</i>	7	0	0	0	0	7
	<i>Lower</i>	8	0	0	0	0	8
<i>White-beaked dolphin</i>	<i>Upper</i>	31	0	0	0	0	31
	<i>Lower</i>	26	0 (+3)	0	0	0	26 (+3)
<i>White-sided dolphin</i>	<i>Upper</i>	2	0	0	0	0	2
	<i>Lower</i>	1	0	0	0	0	1
<i>Lagenorhynchus sp.</i>	<i>Upper</i>	8	0	2	0	0	10
	<i>Lower</i>	2	0	0	0	0	2
<i>Killer whale</i>	<i>Upper</i>	3	8	5	0	6	22
	<i>Lower</i>	1 (+1)	4 (+1)	3	1 (+2)	10	19 (+4)
<i>Northern bottlenose whale</i>	<i>Upper</i>	0	0	0	1	0	1
	<i>Lower</i>	0	0	0	2	0 (+2)	2 (+2)
<i>Sperm whale</i>	<i>Upper</i>	5	20	3	9	1	38
	<i>Lower</i>	5 (+1)	12	3	10	2	32 (+1)
<i>Large whales</i>	<i>Upper</i>	3	4	0	0	2	9
	<i>Lower</i>	8	1	1	0	6	16
Total, groups	Upper	123	48	21	15	43	250
	Lower	99 (+2)	31 (+5)	20	16 (+2)	51 (+5)	217 (+14)

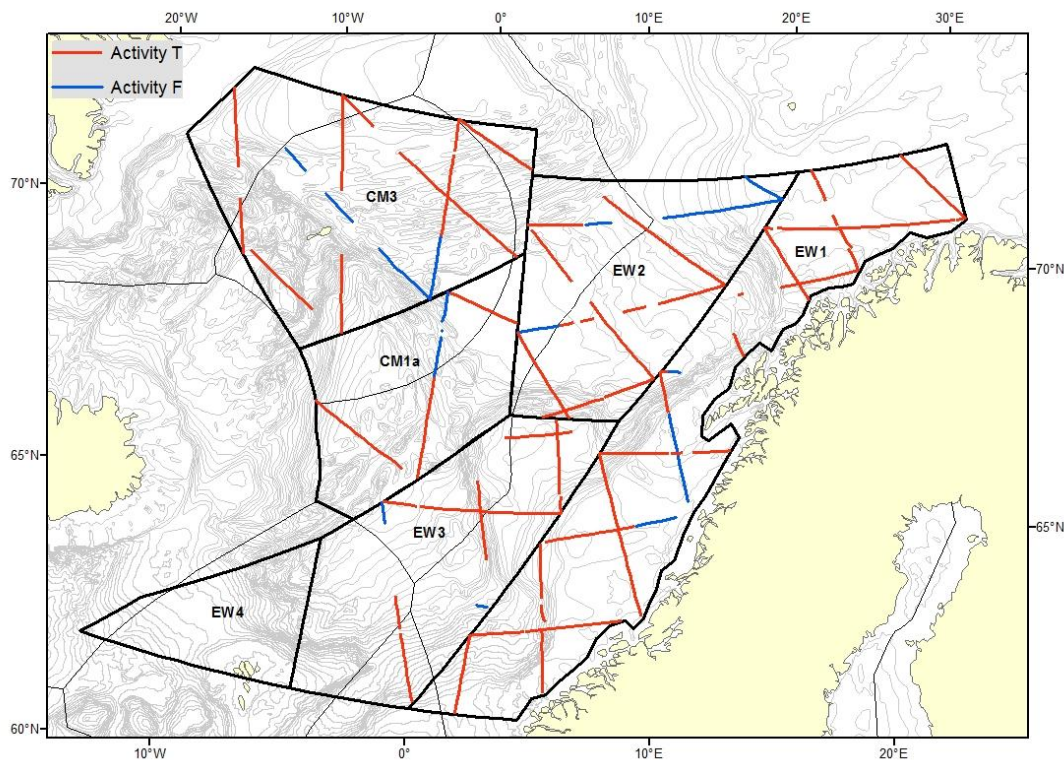


Figure 3. Survey blocks and (preliminary) transects conducted in primary search mode (T, red) and secondary search mode (F, blue).

BRIEF REVIEW OF SURVEY EFFORT FUNDED NATIONALLY BY NAMMCO MEMBER COUNTRIES

Greenland conducted an aerial survey in West Greenland that was combined with the East Greenland coastal survey mentioned above.

The **Icelandic** part of the North Atlantic Sightings survey (NASS 2015) was conducted during 9 June to 10th August 2015. The primary target species were fin whales and common minke whales. However, emphasis was made to identify as many sightings to species as possible, in particular to distinguish fin and blue whales and in the south, sei whales. Identification of long-finned pilot whales was also given high priority. The survey was conducted as a double platform two-way independent line transect survey. The survey was conducted in passing mode on the R/S Árni Friðriksson (AF) with possible delayed closing on the dedicated vessel, R/S Bjarni Sæmundsson (BS).

The BS surveyed in a southern block (IS) between 54°N and 61°N and 15°W to 42°W during the first part and during the second part it surveyed in a northern block (IN) between 65.3 and 72°N from Greenland coast to 12°W, but south of the Norwegian survey area CM2 (Fig. 4). The vessel AF surveyed west of Iceland in the Iceland (IW) Greenland (IG) area between the north and south blocks during the redfish survey and the latter part of the mackerel survey, where some effort at Greenland extended into the south block (IS) and west of 42°W (SW).

The first part of the mackerel survey covered mainly the Icelandic 200 nm EEZ (aerial survey block) (IC), with overlap into the south (IS) and north (IN) blocks and farther east than 10°W (IE) (Fig. 5).

A summary of sightings by area and observation effort is given in Table 3. Fin whales were the most commonly observed species (446 sightings) followed by long-finned pilot whales (108 sightings), common minke whales (92 sightings) and humpback whales (85 sightings).

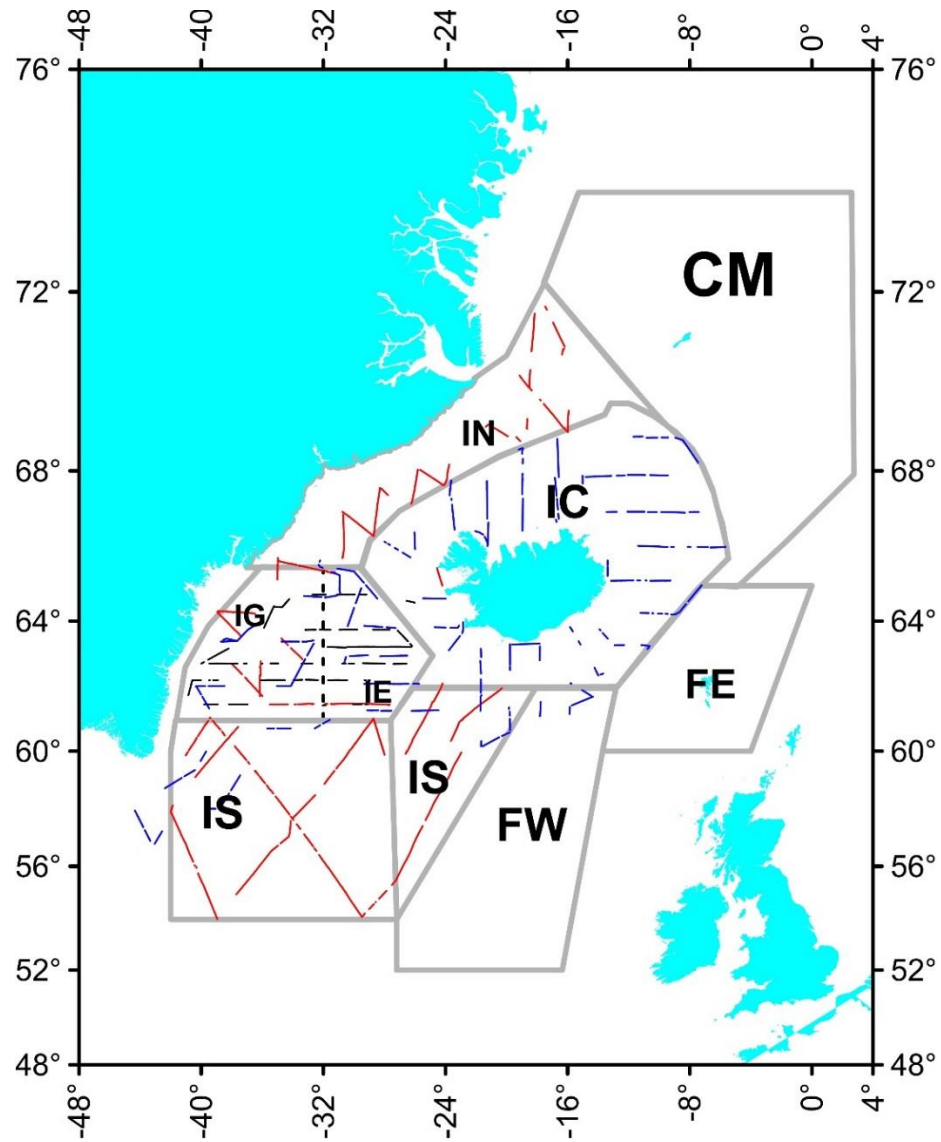


Fig. 4. Survey blocks and realized coverage of the Icelandic shipboard survey. Blue: R/S Árni Friðriksson (ÁF); Red: R/S Bjarni Sæmundsson (BS).

Table 3. Number of sightings of cetaceans encountered during the Icelandic shipboard survey. BP=fin whale, BB=sei whale, BA= minke whale, MN= humpback whale, PM= sperm whale, OO=killer whale, GM=pilot whale, HA=bottlenose whale, D?= dolphin, M?S?= xxxx

Area/Time	nm	BP	BB	BM	BA	MN	B?	PM	OO	GM	HA	D?	M?,S?
IW-I	569	53		3	1	2		1		1		3	
IW-III	435	74	3	5	2	2	55	15		22	4	17	6
IG-I	809	107	1	1	4		3	7	4	5	7	20	
IG-III	434	95	2	6	30	2	37	16		28		6	5
IC	952	26		1	29	16	11	9	12	26		29	10
IN	1128	60		14	14	61	14	1	2	3	1	2	1
IS	2371	27	30	10			6	12		16	1	9	1
<10°W	215	1			12	2		2	2	2	5		5
>42°W	118	4		1			3	10		5		3	1
Total	7031	446	36	41	92	85	129	73	20	108	18	89	29
Podsize		1.35	1.69	1.34	1.07	1.59	1.14	1.12	4.25	26.94	2.78	6.36	2.01

Iceland also conducted a coastal survey during June-July from a high-winged twin-engine Partenavia aircraft. The survey crew consisted of the pilot and cruise leader in the left and right front seats, and 2 primary observers in the right and left rear seats, using the bubble windows.

Realized effort is shown in Fig. 5 and Table 4. Blocks 1 and 8 received nearly complete coverage, while over 70% coverage was achieved in block 9. Blocks 2, 3 and 6 received under 50% coverage, while blocks 4, 5 and 7 were not covered at all. First-pass (*i.e.* non-repeat) coverage for the entire survey was only 37%, the lowest of the 6 surveys attempted since 1987.

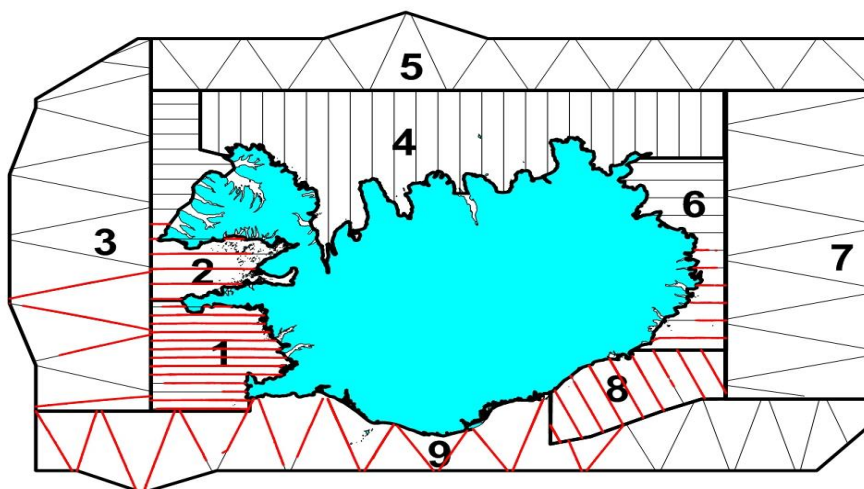


Fig. 5. Stratification and planned (black) and realized (red) effort in the 2015 Icelandic aerial survey.

Table 4. Cetacean sightings during Icelandic Aerial Survey in 2015. BA minke whale; BM blue whale; BP fin whale; GM long-finned pilot whale; GM/LA mixed pilot whale and white-beaked dolphins; LA white-beaked dolphin; MN humpback whale; OO killer whale; PM sperm whale.

STRATUM	BA	BM	BP	GM	GM/LA	LA	MN	OO	PM	PP	OTHE	TOTAL
1	16		1	16	4	29		3		4	5	79
2	1					1	2	1		3	1	9
3	1			3		1	8				1	14
6	2									1	4	7
8	3					2					1	6
9	8	2	4	39	1	8			2	5	3	72
TOTAL	31	2	5	58	5	41	10	4	2	13	16	187

Norway covered the Norwegian Sea together with the Jan Mayen area – see above.

FINANCIAL STATUS FOR THE SURVEYS

As proposed in the original budget there is funding left for initial analyses and development of abundance and for a review meeting of the results of the surveys.

PLAN FOR ANALYSIS AND PRESENTATION OF RESULTS

A first step of the presentation of the results is to prepare standardized maps of all sightings, effort distributed by sea state as well as stratum delineations. This task will be undertaken by Nils Øien (Norway) the following **time schedule** has been decided:

1 February 2016: submission of raw positional data or shapefiles to Nils Øien

1 March 2016: draft maps are being circulated

1 April 2016: final maps should be ready after review by survey leaders.

For the analyses of the survey results the following schedule was decided for the initial analyses:

Analyses of **pilot whale abundance** from the Faroese (and the Icelandic) survey will be conducted by contracting Daniel Pike and the group suggested that could be paid by NAMMCO using the remaining MFA funds.

Analyses of the **Greenland** aerial survey data for the target species (minke whales, fin whales and humpback whale) will be conducted by the Greenland Institute of Natural Resources (Hansen and Heide-Jørgensen).

Analyses of minke and fin whale data from the Norwegian surveys will be conducted by the Institute of Marine Research Bergen (Øien).

The Iceland minke and fin whale data (incl. Faroese sightings) will be analysed by Daniel Pike and the group suggested that could be paid by NAMMCO using the remaining MFA funds.

The preliminary time schedule for the analyses was decided as follows:

Mid-April 2016: short update to group on progress of the analyses.

Mid-May 2016: Initial analyses should be completed and preliminary reports circulated for minke, fin whale and pilot whales.

Post-cruise report of the NASS2015 Steering Committee

A review meeting of the involved researchers is planned for mid May 2016. This will be a meeting of the NAMMCO Abundance Estimates Working Group. The location of the meeting will likely be the Greenland Institute of Natural Resources offices in Copenhagen.

Initial analyses of remaining species:

Greenland will complete a first presentation of humpback whale abundance estimates by mid May 2016.

Preliminary abundance estimates for other species (such as harbour porpoise, humpback whales (Iceland and Norway) and pilot whales and dolphins (Greenland)) will be presented in fall 2016 at next NAMMCO SC meeting.

DATA DEPOSITION AND FUTURE DATA SHARING

Data from the surveys will be deposited with NAMMCO secretariat, but may also be deposited at IWC if required according to the RMP or the AMWP.

It was agreed to restrict the distribution of the raw data from this survey to only include the researchers involved. Data dissemination outside the survey group depends on agreement in the group.

FUTURE OF THE NASS2015 STEERING GROUP

With reference to NAMMCO's FAC, it is recommended that the NASS2015 Scientific Steering Group has, with the circulation of this report, completed its task. The follow-up on the survey and the development and approval of the abundance estimates are from now on deferred to the NAMMCO SC and no further activities are planned for the NASS2015 Scientific Steering Committee.