# SECTION 3 - SCIENTIFIC COMMITTEE

# 3.1
# REPORT OF THE SEVENTEENTH MEETING OF THE NAMMCO SCIENTIFIC COMMITTEE

## EXECUTIVE SUMMARY

The 17th meeting of the Scientific Committee (SC) was held as a video-conference between Tromsø, Nuuk, and Torshavn, April 21-23, 2010 due to the eruption of the Icelandic volcano Eyjafjallajökull.

The SC had reports from four NAMMCO SC Working Groups (WG) available: WG on Abundance Estimates (Annex 1); WG on Walrus (Annex 2); WG on Marine Mammals and Fisheries Interactions (Annex 3); and WG on Assessment (Annex 4). It had also the 2009 report of the ICES Study Group for By-catch of Protected Species, and the 2009 report of the ICES/NAFO WG on Harp and Hooded Seals.

## THE ROLE OF MARINE MAMMALS IN THE ECOSYSTEM

In October 2009, NAMMCO applied to the Nordic Council of Ministers to fund a scientific network project as defined by the WG on Marine Mammals and Fisheries Interactions at its 2009 meeting and recommended by the SC and Council. The project was funded, and a kick-off meeting was held in March 2010 to compile proposals and budgets for ecosystem modelling of the Barents' Sea and Icelandic Waters (Annex 3). Project coordinators are Walløe and Butterworth.

The **SC concludes** that there is a sufficient basis for proceeding with the planned modelling, and funding should include both the Barents' Sea and Icelandic waters. It **agrees** that funding should be sought first from the Nordic Council Ministers, then from the European Union, and finally from Norwegian sources. The **SC strongly recommends** the project, and it **notes** that the steering group need no further input from the SC, and that it will report to the SC.

In 2006, adult Barents Sea **harp seals** showed a significant drop in body weight, condition index, and blubber thickness compared to 1992-2001. Updated information is needed to assess if body condition remains low and if it can be linked to an observed reduction in recruitment after 2003.

## BY-CATCH OF MARINE MAMMALS

A joint NAMMCO/ICES workshop on by-catch monitoring will be held late June 2010, to: 1) review and describe advantages and disadvantages of existing observation schemes for marine mammals and seabirds, and 2) to recommend best practice when establishing and implementing by-catch observation schemes. The workshop will aim to develop a training manual for by-catch monitoring of protected species. The SC is part of the steering group, and NAMMCO is funding 4 of the expected 20 to 25 invited experts at the meeting.

In 2008 the SC strongly recommended that ***Norway*** complete its analysis of by-catch and evaluation of a new by-catch monitoring system. Preliminary analyses have been made, and final results are expected at the NAMMCO/ICES workshop. The **SC looks forward** to the report that is scheduled for publication next autumn.

**Marine mammal by-catch monitoring**

***Iceland*** provided new information on by-catch monitoring of marine mammals**.** Information on by-catch and fishing effort was obtained from several sources. A total of 266 by-caught marine mammals was reported in 2009 (Table 1), with all reported by-catch being from gill nets. No by-catch was reported in logbooks for other fisheries than the lumpsucker fishery since a new electronic logbook system had been implemented in 2008.

Four marine mammal species were reported entangled in the lumpsucker fishery in 2009. Information from 215 fishing trips showed marine mammal by-catch in about a third of the trips, which strongly indicates relatively high by-catch rates of some marine mammals in the ***Icelandic*** lumpsucker fishery.

Fishery research surveys provided an estimate of 374 (95% CI: 41 to 560) by-caught **harbour porpoises** in the cod gill-net fishery in March and April 2009. Lower by-catch rates and insufficient effort data from the lumpsucker fishery prevent the estimation of total by-catch numbers for other species.

| **Species** | **Latin name** | **Fishing gear** | **Reported** |
|---|---|---|---|
| Harbour porpoise | *Phocoena phocoena* | Gill-net | 16* |
| Harbour porpoise | *Phocoena phocoena* | Lumpsucker gill-net | 34 |
| Bearded seal | *Erignathus barbatus* | Gill-net | 1 |
| Grey seal | *Halichoerus grypus* | Lumpsucker gill-net | 26 |
| Harbour seal | *Phoca vitulina* | Gill-net | 3 |
| Harbour seal | *Phoca vitulina* | Lumpsucker gill-net | 94 |
| Harp seal | *Pagophilus groenlandicus* | Gill-net | 23 |
| Harp seal | *Pagophilus groenlandicus* | Lumpsucker gill-net | 34 |
| Unidentified seal | | Lumpsucker gill-net | 35 |
| Marine mammal total | | | 266 |

**Table 1**. Marine mammal by-catch reported in Icelandic fisheries in 2009. * Total estimated by-catch in March and April was 374 (95% CI: 41 to 560).

The ***Faroe Islands*** do not at present have mandatory reporting of by-caught marine mammals. A new electronic logbook system for all vessels larger than 15 BRT is under development, and planned to be enforced in 2011. The Ministry of Fisheries has secured that by-catch reporting becomes mandatory and implemented in the new system. By-catches of large whales have traditionally been reported directly to the Museum in Tórshavn.

The **SC supports** the effort of ***Iceland***, and **recommends** that countries strengthen their efforts to implement by-catch monitoring systems that allow total by-catch estimation. More detailed data than presented here by Iceland are needed for this. The **SC notes** again that some by-catches are reported as directed catch, and it **reiterates** the recommendation that ***Greenland*** evaluate the degree to which by-catch is reported as catch.

## SEALS AND WALRUS STOCKS - STATUS AND ADVICE TO THE COUNCIL

### Harp Seals

The ICES/NAFO Working Group on Harp and Hooded Seals (WGHARP) met in August 2009 to provide catch advice for harp seals in the White Sea/Barents Sea and Greenland Sea.

**White Sea/Barents Sea**

A Russian survey in 2009 estimated the number of harp seal pups in the White/Barents seas as 157,000 (95% CI: 123,680 - 190,320), which is significantly lower than the prior estimate from 2004. The cause for the low pup production might be reduced adult recruitment due to past juvenile mortality, or unobserved mortality of adults in recent years. Alternatively, the number of pups might be underestimated if pupping is now occurring in unknown locations outside the traditional pupping areas.

The White/Barents seas stock is now considered data-rich. The decline in pup production after 2003 could not be accounted for by the existing population model. Sustainable catch levels were therefore calculated by the Potential Biological Removal (PBR) approach that estimated the total allowable catch from the White/Barents seas harp seal stock to be of no more than 30,062 animals.

**Greenland Sea**

A ***Norwegian*** survey in 2007 estimated 110,530 (95% CI: 56,080-164,580) harp seal pups in the Greenland Sea, and reproductive data were collected in 2009 to supplement the survey.

The Greenland Sea stock is now considered data-rich, with a population model estimating a stock size of 810,600 (95% CI: 487,100-1,134,000) animals for 2009. The model estimates a replacement yield of 30,865 animals for 2010, and it estimates that total annual removals of 42,400 1+ animals (or an equivalent number of pups, with one 1+ seal being balanced by 2 pups) over a 10-year period implies a 80% chance that the population will remain above 70% of $N_{max}$, with $N_{max}$ defined by the 2007 abundance estimate. Any allowable catch of this magnitude should be contingent on an adequate monitoring scheme to detect any adverse population impacts.

White coat pups have arrived to Southwest ***Greenland*** with drift ice from the East every year since 2007, when such an influx was observed for the first time with 1,000 pups. In 2010, the first pups were seen on March 26. The timing of the pups indicates that they belong to the Greenland Sea stock. How many seals that are born in this area far from the traditional breeding grounds, are unknown.

**Northwest Atlantic**

After a period of high catches between 1996 and 2006 (on average 272,600 taken per year), Canadian catches have now declined to approximately 72,000 in 2008 because of ice conditions and poor markets. Since 1980, the ***Greenland*** catches increased relatively steadily to a peak of approximately 100,000 in 2000, whereafter they have varied around an average take of just over 80,000 individuals.

Aerial surveys off Newfoundland and over the Gulf of St. Lawrence in March 2008 estimated a total pup production between 1,648,800 (CV: 7.2%; photo estimate) and 1,076,600 (CV: 5.7%; visual estimate). This indicates a pup production that is similar to, or higher than, that seen over the past decade. Applying a population model to the data, it estimates a total population size between 6,851,600 (95% CI: 5,978,500-7,697,200) and 8,238,500 (95% CI: 6,774,300-9,540,300) individuals.

The **SC recommends** reconnaissance surveys to investigate the possible presence of whelping patches in untraditional areas, both in the Greenland Sea (*e.g.* south of 67°N in East Greenland), the Denmark Strait and Southwest Greenland, and in the Barents Sea (southeast and north). Such surveys have been proposed in ***Norway*** and ***Greenland*** but they have not yet received funding. The **SC also recommends** continued sampling of biological parameters, and studies on stock identity.

**New request 2-1-11:** *The Scientific Committee is requested to evaluate how a projected increase in the total population of Northwest Atlantic harp seals might affect the proportion of animals summering in **Greenland**.* The SC has no tradition of establishing WGs on harp seals. It therefore **recommends** that Greenland forward the request to ICES/NAFO.

**Hooded seals**

**Greenland Sea**

A ***Norwegian*** survey in the Greenland Sea pack-ice (West Ice) in 2007 estimated 16,140 (95% CI: 11,950- 20,380) hooded seal pups.

A total of 396 bluebacks was taken by ***Norwegian*** scientists in 2009, in order to continue a time series that started in 1995 on the condition of bluebacks in the Greenland Sea. Further sampling will be conducted in July 2010 with a planned minimum take of 200 adults.

The **SC strongly recommends** facilitating the funding and execution of ***Norwegian*** reconnaissance surveys for relocated pupping areas of hooded seals in the Greenland Sea. It also **recommends** a Norwegian health project that aim to identify biological factors that contribute to the prevailing low abundance of hooded seals in the Greenland Sea.

**Northwest Atlantic**

Satellite tracking has shown that young hooded seals come to Southeast ***Greenland*** during their first spring or summer, and that they usually stay in this area during the first years of their life. Satellite tracking will continue in 2010, where tags will be placed on pups off Newfoundland.

**Ringed seal**
Diving behaviour of ringed seals in ***Greenland*** will be monitored by satellite tags at Ilulissat Icefjord in 2010, and Greenland plans for aerial surveys and satellite tracking of ringed seals in Baffin Bay in relation to oil prospecting, as well as for opportunistic sampling for genetic analysis.

The **SC is pleased** to see new projects on ringed seals; it **reiterates** the recommendation for abundance estimates from sea ice in offshore areas and increased tagging effort for a better understanding of stock structure.

**Grey seal**
The first confirmed sighting of a grey seal in ***Greenland*** was made in South Greenland in 2009. The **SC notes** this interesting information and **recommends** that Greenland gather further information on grey seals during fieldwork on harbour seals. Given the possibility of a small isolated stock in Southeast Greenland, the **SC recommends** that grey seals be protected against hunting in Greenland.

The new ***Norwegian*** management plan for coastal seals has in part been implemented. Population modelling efforts are planned, with reproductive data being collected from catches. The **SC reiterates** the recommendation that the Russian grey seal colonies on the coast of Murmansk be surveyed again.

No progress has been made on the estimation of population size and removal levels in the ***Faroe Islands***. There is no compulsory reporting of removals in connection with fish farming. The monitoring of removals has been assigned to the Ministry of Fisheries, and an abundance survey is planned for the coming autumn. The **SC reiterates** that all efforts should be made to provide proper estimates of population size and catch for the next annual meeting.

An ***Icelandic*** autumn survey in 2009 indicated a grey seal pup production that was somewhat lower than estimated in 2008. Direct takes have decreased in recent years (around 45 animals in 2009), making by-catch the likely main removal method. No reliable estimate of total by-catch is available.

The **SC strongly recommends** that all directed catches and by-catches are reported from all areas, and it **reiterates** the recommendation of a WG meeting on coastal seals by early 2011.

**Harbour seal**
A small colony of about 40 adult harbour seals was found in southeast ***Greenland*** in 2009. Eight of the seals were equipped with satellite-linked transmitters, with seals staying mainly within a range of 10 km of the colony. Only 2 seals have so far made excursions of more than 50 km. The **SC welcomes** the information and **recommends** the continuation of the study.

Harbour seals have disappeared or become very rare all along the West ***Greenland*** coast and the **SC reiterates** its recommendation of a total ban on the hunt of harbour seals in Greenland.

***Norway*** plans aerial surveys for 2011 and 2012, and the species is included in a larger ecosystem project of the two Norwegian fjords Porsanger and Hardanger.

The last overall harbour seal survey in ***Iceland*** was in 2006. There are annual counts by the Seal Centre in Northern Iceland in a small high-density area, with the last count being around 1,000.

The **SC reiterates** the recommendation that a formal assessment of harbour seals in all areas (**R.2.5.2**) be carried out by a WG meeting on coastal seals in 2011.

**Bearded seal**

A bearded seal was instrumented with a satellite transmitter in summer 2009 in the area around Cape Farewell, ***Greenland***. The animal has resided mainly within a radius of 5 km from the tagging location.

There are plans for tagging more animals around Cape Farewell during summer 2010, and ***Greenland*** is planning acoustic monitoring and tagging in relation to oil exploration in Baffin Bay.

**Noting** that only a few studies have been initiated for this data-poor and exploited species, the **SC reiterates** the recommendation to renew efforts towards information on biology, abundance and stock status in view of an assessment.

**Walrus**

The WG on walrus met November 2009 (Annex 2). The report was approved inter-sessionally by the SC (Annex 5) and presented to the Management Committee for Seals and Walrus on 7 January 2010.

***Greenland*** is planning tagging and DNA-analysis of walruses from Upernavik and Ummannaq to determine the stock origin of these animals. A user's knowledge interview on walrus in West Greenland is planned for 2010.

The **SC notes** that the quotas for the West ***Greenland*** –Baffin Island stock follow the advice on sustainable removals, while the quota for the Baffin Bay stock (Northwest Greenland) is higher than the advice (a preliminary 2010 quota of 75 animals compared with an advice of no more than 68 animals). It r**ecommends** that total removals be smaller than or equal to recommended removals.

In 2009, the Management Committee for Seals and Walrus recommended that the Russian authorities facilitate the Joint ***Norwegian***-Russian research programme on walrus and beluga ecology and the Management Committee for Seals and Walrus agreed to send recommendations on the issue (NAMMCO 2010a, p.95). The **SC urges** that it be done as soon as possible.

## CETACEANS STOCKS - STATUS AND ADVICE TO THE COUNCIL

### Abundance estimates from T-NASS

Endorsed T-NASS abundance estimates are shown in Table 2. Endorsed estimates from West ***Greenland*** for **pilot whale, white-beaked dolphin** and **harbour porpoises** were welcomed as the first estimates for these species in this area where they are harvested.

Approximate point estimates for the whole North Atlantic are 50,000 for **fin whales**, 15,000 for **humpback whales**, and 150,000 for **minke whale**.

The **SC recommends** that the ***Icelandic-Faroese*** data for **northern bottlenose whale** be examined in combination with CODA data and compared with earlier surveys for trend information. The **SC notes** that acoustic survey data cannot be analysed for this species because it cannot be identified in the recordings.

Acceptable **pilot whale** estimates for the major areas (***Iceland and Faroe Islands***) are still missing. The **SC urges** this analysis (including an index of relative abundance for areas common to all surveys) because the best available estimate is too old (1989) for management purposes.

Estimates are still missing for several **dolphin species** from several areas, including the ***Icelandic*** coastal area, the Icelandic-***Faroe Islands*** area and off ***Norway***.

**Harbour porpoise** was a target species for ***Iceland***, but an abundance estimate is still lacking for this area.

No abundance estimates are yet available for **sperm whale**. The **SC recommends** that estimates be obtained for both acoustic and visual data for the ***Icelandic*** and ***Faroese*** area, and it **notes** that the Icelandic acoustic data are being analysed and prepared for abundance estimation.

The **SC reiterates** the importance of producing a document that describes the general distribution of cetaceans throughout the entire T-NASS survey area, including extension areas.

The **SC recommends** that ***Greenland*** analyses and publishes estimates from the shipboard survey in 2007 to allow, if possible, for density comparisons to the aerial survey estimates from September. The **SC notes** that such comparisons may not be possible because of the different techniques and coverage of the 2 surveys.

The **SC recommends** that integrated model-based analyses of CODA and T-NASS data be undertaken as soon as possible. Most new information would be gained by estimates for **pilot, minke, fin** and **sperm whales** as well as **white-beaked dolphins**.

| **Survey Areas** | **West Greenland** | **Iceland Coastal** | **Iceland-Faroes** |
|---|---|---|---|
| Survey type | Aerial | Aerial | Shipboard |
| Fin whale | *4,359*<br>*(1,879-10,114) n* | - | 20,613<br>(14,819-25,466) n<br>26,117<br>(17,401-39,199) p |
| Minke whale | 16,609<br>(7,172-38,461) pa<br>22,952<br>(7,815-67,403) pa | 15,055<br>(6,357-27,278)<br>10,680<br>(5,873-17,121) | 10,782<br>4,733- 19,262)n |
| Humpback whale | 3,272<br>(1,230-8,710) pa | 1,242<br>(632-2,445) p | 11,572<br>(4,502-23,807) n |
| Pilot whale | **2,976**<br>**(1,178-7,515) n** | - | **Not accepted** |
| Sperm whale | - | - | To be done |
| Bottlenose whale | - | - | To be done |
| Harbour porpoise | **33,271**<br>**(15,939-69,450) pa** | To be done | - |
| White-beaked dolphins | **9,827**<br>**(6,723-14,365) p** | To be done | To be done |

**Table 2.** T-NASS (2007) abundance estimates endorsed by the SC for assessment purposes. Estimates in bold are first estimates for the species in the area, estimates in *italic* have been endorsed but need further work. *Legend*: n, uncorrected for bias; p, corrected for perception bias; a, corrected for availability bias.

**Future large-scale surveys**

Obvious years for the next large-scale survey would be 2013 to 2015. The **SC recommends** a WG on future surveys to initiate planning, provide directions and negotiations with survey partners as soon as feasible. This is best done by bringing in participation from all potential partners. The **SC recommends** coordination at or beyond the T-NASS level.

**Fin whale**

**<u>Central North Atlantic</u>**

**R.3.1.6:** The Council had requested the SC to complete an assessment of fin whales in the North Atlantic, including estimates of sustainable catch levels in the Central North Atlantic.

The SC considers that the IWC RMP (IWC 1994a, b) provides an appropriate basis to calculate catch limits and address the Council's request. The RMP can be applied to a "*Small area*", or to combinations of such *Small areas*. Since in practice catches would be taken in the West Iceland (WI) sub-area, the **SC considers** that the relevant area is WI, or the combination of the WI and the East Greenland (CG) sub-area.

***Assessment***

The **SC notes** that the operating models developed for the seven stock structure hypotheses by the IWC SC in the RMP testing process provide an appropriate assessment of the resource.

***Management advice***

The two relevant RMP variants consider either only the WI sub-area, or the sub-area combination WI-CG, as the unit for which a strike limit is calculated. The IWC SC RMP trials show that the latter choice 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 **SC considers** that the WI-CG variant constitute an appropriate basis for a “safe” removal recommendation.

The RMP output depends on the chosen tuning level (TL). The IWC SC had recommended to their Commission, based on simulation trials that for single stocks with certain stock structure, that TL ranging from 60% to 72% were safe from a conservation perspective (IWC 1992). The IWC SC RMP implementation process had extended these trials to cover stock structure uncertainty for the 72% tuning. The RMP’s output is a strike limit of 87 fin whales for the 72% tuning, and 154 for the 60% tuning; the latter output is close to the earlier recommendation of the NAMMCO SC that a total annual removal of 150 whales from this population would be sustainable (NAMMCO 2007).

The **SC considers** that annual strikes of up to 154 fin whales from the WI Sub-area are sustainable at least for the immediate 5-year period. It **notes** that the RMP variant with a 60% TL has yet to be long-term (100 years) simulation tested for trials involving stock structure uncertainty. While simple extrapolation from the results of trials mentioned above suggests that catch levels for this tuning would be safe, the **SC recommends** that the simulation trials required to check this be carried out as soon as possible, with the recommendation regarding the long-term sustainable level of catch to be reconsidered in the light of these results.

***Future work***

The **SC recommends** that the simulation trials required to check if catch levels for 60% tuning are safe should be carried out as soon as possible. It also **recommends** further studies to help distinguish between alternative stock structure hypotheses, particularly in and around the area of proposed whaling, using several different approaches such as genetics, satellite telemetry and photo-identification.

**Humpback whale**

**<u>West Greenland</u>**

**R.3.2.5:** A new Council request asked the SC to assess the sustainability of yearly catches of 5, 10 and 20 humpback whales off West Greenland.

The SC considers that a management procedure that has been simulation-tested by the IWC Scientific Committee for West Greenland humpback whales (Allison *et al.* 2009) provides an appropriate basis to calculate catch limits and address the Council’s request.

It is assumed that humpback whales in West Greenland comprise a separate summer feeding aggregation that is best treated as a separate management unit (IWC 2002 and 2009). Most of the animals in this aggregation spend the winter breeding season in the West Indies together with individuals from other summer feeding aggregations in the North Atlantic.

***Trend data***
A time series of uncorrected abundance estimates from aerial surveys showed an annual rate of increase of 9.4% $yr^{-1}$ (SE 0.01) between 1984 and 2007. Similar or even higher rates of increase have been observed for this species in other areas, including ***Iceland*** (Pike *et al.* 2005, 2009) and Antarctica (Matsuoka *et al.* MS 2004).

***Assessments***
There is statistically decisive support for the rejection of traditional density-regulation as an appropriate model for the long-term dynamics of humpback whales off West Greenland. The dynamics are better described as damped cyclic, although a density-regulated, as well as an exponential model, provides good fits when initialized recently (last two decades). The assessment estimated an equilibrium population abundance between 1,700 (90% CI, 1,500 to 2,000) and 2,700 (90% CI, 2,300 to 3,100) whales, a 2008 depletion ratio between 0.88 (90% CI, 0.44 to 1.6) and 1.3 (90% CI, 0.71 to 2.4), a 2008 exponential growth rate of 0.09 (90% CI, 0.06 to 0.11), and a yearly replacement yield between 160 (90% CI, 72 to 370) and 220 (90% CI, 96 to 510) whales in 2008.

The **SC notes** that the problem identified in explaining the long-term dynamics of West Greenland humpback whales with a traditional density regulated model is consistent with earlier findings on the long-term dynamics of humpback whales throughout the North Atlantic.

***Management procedure***
The **SC finds** that the AWMP-C procedure (Witting 2008, IWC 2009) is appropriate for providing management advice for West Greenland humpback whales. For a need of up to 20 humpback whales, this procedure sets the yearly strike limit for a 5-year period equal to 2% of the lower $5^{th}$ percentile of the most recent abundance estimate. The procedure is simulation-tested for long-term performance on West Greenland humpback whales (Allison *et al*. 2009), with results showing that the depletion level after 100 years is well above 60% of the carrying capacity for all trials.

***Management advice***
Using the fully corrected 2007 estimate of 3,272 (CV 0.50) humpback whales, off West Greenland, the **SC concludes** that strikes of up to 20 humpback whales per year from 2010 to 2015 would be safe. This number is not to be compared directly with the lower 90% credibility estimate of the replacement yield (72-96 whales per year). The replacement yield is based not only on the current abundance but also on the estimated increase in abundance, while the AWMP-C procedure was constructed to ensure safe long-term catches for humpback whales given a need of up to 20 humpback whales per year. The **SC notes** that the assessment concludes that the probability that humpback

whales off West Greenland will continue to increase is larger than 0.99, even with a total annual removal of 20 whales over a 5-year period.

Should management advice on West Greenland humpback whales turn out to be a reoccurring request, the **SC notes** the need to consider more detailed simulation testing of the AWMP-C procedure before the procedure is used for the third time to provide management advice for a 5-year period.

**Sei whale**

**R.3.5.3:** A new Council request asked the SC to make a state of the art investigation about the possibility of providing a status assessment for sei whales in East and West ***Greenlandic*** waters and in waters west of ***Iceland***.

Abundance estimates are available for the Central North Atlantic in 1989 and 1995, and a new estimate could be produced for 2007. For the East and West Greenland area there are estimates from 2005.

These estimates are incomplete in temporal and spatial coverage, but they could be used as minimum estimates. The **SC concludes** that assessments with minimum estimates of sustainable yield should be feasible once a minimum abundance estimate for 2007 is produced.

The **SC recommends** that sightings surveys, targeted at sei whales should be conducted in the Central North Atlantic during peak abundance of the species in these waters, *i.e.* late summer and fall. Satellite tagging of sei whales off ***Iceland*** and West ***Greenland*** should be conducted to complement recent tracking off the Azores.

**Minke whale**

**Central North Atlantic**

**R.3.3.4:** The Council had requested the Scientific Committee to conduct a full assessment, including long-term sustainability of catches, of common minke whales in the Central North Atlantic once results from the 2009 survey become available.

The **SC considers** that the IWC RMP (IWC 1994a, b) provides an appropriate basis to calculate catch limits and address the Council's request. The RMP can be applied to a "*Small area*", or to combinations of such *Small areas*. For the Central North Atlantic minke whale population, four such areas are concerned: the Jan Mayen area (CM), the Icelandic coastal area (CIC) in which Icelandic catches would concentrate, the East Greenland area (CG) and the Icelandic pelagic area (CIP) (Fig. 1 of the WG report).

***Stock structure***

In line with past views expressed by the SC and the IWC SC, a one-stock hypothesis for the Central North Atlantic area is assumed.

***Abundance***

An aerial survey of ***Icelandic*** coastal waters in 2009 produced a cue counting estimate of 5,900 minke whales (95% CI, 3,423 to 8,803). This estimate is not *h*(0)-corrected for visible cues missed by observers (perception bias). Although the 2009 estimate is biased downwards and should be $h(0)$-corrected, it does confirm the decreased abundance in Icelandic coastal areas that was first detected in 2007.

Estimates of minke whales from ***Icelandic*** aerial and shipboard surveys of the central North Atlantic during 1987-2007 were reviewed. Comprehensive coverage took place in 1987, 2001 and 2007, with abundance estimates totalling 37, 62 and 21 thousands of whales respectively. The drop from 2001 to 2007 is primarily a consequence of a much reduced estimate from the aerial surveys of the Icelandic coastal region. Possible reasons for the decrease include changes in spatial/temporal distributions as the most likely explanation. While a population decrease seems unlikely, it cannot be completely excluded. The 326 catches in the area over the past 7 years cannot have caused a decline.

***Assessments***

Assessments of the Central North Atlantic minke whale population have been presented in previous reports (NAMMCO 2000, 2005 and 2010c). They uniformly show a resource reduced only slightly below its pre-exploitation level, because cumulative past takes have been small relative to recent abundance estimates. There was insufficient time to rerun these analyses to account for the most recent survey data. However, these further data are not such as would result in a qualitative change to the earlier results mentioned above.

***Management Advice***

In the absence of any indication of stock structure for minke whales within the Central North Atlantic the **SC considers** it appropriate to run the RMP on the whole Central North Atlantic (CM+CIC+CIP+CG), with catch cascade allocation of catches to the four small areas. There was, however, insufficient time to complete these calculations.

For the CIC *Small area*, there are 4 aerial survey estimates (1987, 2001, 2007 and 2009) for input to the RMP. All estimates have been formally approved except for the 2009 estimate, which needs to be examined for $h(0)$ correction. Ideally, all estimates should be used for input, and they should be comparable and corrected for known biases. The **SC agreed** to explore both the option of including and excluding the 2009 estimate.

The IWC SC has recommended to their Commission, on the basis of simulation trials, that for single stocks, for which there is no stock structure uncertainty, TL for the RMP ranging from 60% to 72% were safe from a conservation perspective (SC/17/AS/O12).

The **SC concludes** that annual removals of up to 216 minke whales from the CIC area are safe and precautionary. The advice is based on the RMP TL 60%, and it is conservative in the sense that it is based on the uncorrected downward biased 2009 abundance estimate as well as the lower of two accepted abundance estimates from 2007. Similarly, an annual removal of 121 minke whales from the CM area is a safe and precautionary management advice.

The basis on which the RMP was tested indicates that these levels can apply for the next 5 years before a revision is needed. However, in case further data becomes available, including a revised abundance estimate for 2009 and RMP application to the combined CM+CIC+CIP+CG area, the management advice could be revised sooner. The **SC recommends** that **Council should decide** on the duration of the advice.

***Future work***

The **SC recommends**:

- To calculate, as soon as possible, catch limits based on running the RMP on the Central North Atlantic medium area, with catch cascade allocation of catches to small areas.
- That the 2009 survey be *h*(0)-corrected as soon as possible, and that the management advice be adjusted.
- That the 2007 aerial survey estimate be corrected for *h*(0) and distance measurements error.
- That line transect density should be estimated for the 2007, 2008 and 2009 aerial surveys.
- Further studies on stock structure should be conducted using genetic techniques and satellite tracking.
- That ecological and environmental changes should be examined to explain the suggested large-scale re-allocations of minke whales between different parts of the North Atlantic.

**Narwhal and beluga**

The **SC recommends** proceeding with the organisation of an age determination workshop for narwhal and beluga, and to consider the working papers for an age determination volume of the NAMMCO Scientific Publication Series.

A narwhal survey was conducted in the North Water polynya in May 2009 and it will be repeated in 2010 due to unusually large amounts of open water in 2009. The next winter/spring survey off West ***Greenland*** is planned for 2012. A tagging programme for narwhals in East Greenland is scheduled for August 2010, and tagging in West Greenland continues in Qaanaq (June-July) and Uummannaq (November-December).

The **SC recommends** a JWG meeting with assessment updates no later than the winter 2013/14, with final timing being determined by the parties (***Greenland*** and Canada).

The **SC is pleased** to see that the quotas for narwhal and beluga in ***Greenland*** are matching the advice on sustainable removals. It **reiterates** that all “struck and lost” animals are included in the advice, and **again strongly recommends** that “struck and lost” data be collected from all areas and types of hunt. For beluga it also **reiterates** the recommendations that catches should be banned:

- south of 65°N
- in May to October beteen Sisimiut and Maniitsoq
- in June to October in Disko Bay
- in June to August between Uummannaq and Qaanaaq.

**Northern bottlenose whale**
Preliminary feeding data were presented on 36 northern bottlenose whales stranded/landed/by-caught in the ***Faroe Islands*** and 6 whales stranded in ***Iceland***. The **SC was pleased** that the analysis is ongoing, and **recommends** its completion and publication.

**Killer whale**
The effects of low frequency military sonars (1-7 kHz) on whales are being investigated in ***Norway***, with target species being killer whales, **pilot whales** and **sperm whales**.

**Pilot whale**
Attempts to track animals will continue on the ***Faroe Islands***, and a planned **harbour porpoise** aerial survey in summer 2010 will gather information on pilot whale group size. The **SC reiterates** its recommendation on the timely implementation of a 3-year catch sampling programme, so that a long term cost-effective monitoring programme can be defined and implemented.

**White-beaked, white-sided and bottlenose dolphins**
The **SC notes** that the data on life history and abundance for any of the 3 species is still not sufficient for an assessment and **recommends** that ***Faroese*** samples for diet and life history parameters from 350 white-sided dolphins be finalised and that an abundance estimate from the 2007 surveys be attempted.

**Harbour porpoise**
A dedicated harbour porpoise aerial survey is planned in the ***Faroe Islands*** in summer 2010.

***Greenland*** is preparing for an assessment of this species as requested by Council (**R.3.10.1**), and the **SC recommends** that an assessment meeting for harbour porpoises in all areas be held during the winter 2011/12. It also **recommends** that total removal estimates be obtained for all areas before the planned WG meeting, and that abundance estimates from the 2007 survey in ***Iceland*** and the 2010 survey in the ***Faroe Islands*** become available before the meeting.

**Bowhead whale**
Biological samples have been collected from the 6 bowhead whales taken in West ***Greenland*** over the 2-year period 2009 to 2010.

A walrus survey in the Northeast Water polynya in 2009 encountered 13 sightings of bowhead whales. The spring aggregation in the West ***Greenland*** Disco Bay area will be counted by a planned survey in 2012.

## GENERAL MODELS FOR MANAGEMENT

The **SC noted** the usefulness of basing its advice on the large amount of simulation testing and other work conducted within the IWC SC using the RMP approach. It also noted that this might not be possible or appropriate for all stocks. In addition, reliance on the IWC work may limit the possible questions that can be raised by the NAMMCO Scientific Committee. The **SC recommends** that the Large Whale Assessment WG investigate how NAMMCO can take over a larger and more direct role in this work in the future so that it can be less dependent on other organizations.

The **SC also recommends** that the Large Whale Assessment WG at its next meeting should investigate the trade-off space between catches and conservation over a range of tuning levels for management procedures that have already been thoroughly investigated but not examined in detail by NAMMCO.

## NAMMCO SCIENTIFIC PUBLICATIONS

The NSP volume on **harbour seals** in the North Atlantic is planned for publication before the summer 2010. A contribution list is ready for a new volume on **walrus**, and the possibility of a volume on **age determination** is being examined.

For future NSP volumes, the SC **agrees** that contributions are published on-line when review is finished on a first-in first-out basis. The National Library of Norway had been approached for the production of electronic versions of the past NSP volumes to ensure on-line publication of the whole series.

## DATABASES ON ABUNDANCE AND CATCHES

The **SC agrees** that a NAMMCO database on abundance should hold all endorsed estimates, and that an established email group should agree on a database format and report back to the Secretariat as soon as possible.

The **SC agrees** that NAMMCO should not attempt to hold a complete, detailed database of historical catches to be used for generating catch series for assessment work. These data can instead be obtained from databases in different countries, or from IWC. NAMMCO should instead hold relatively simple catch series that provide insights in the number of individuals of different species harvested in different areas.

The **SC agrees** that an established email group should agree on a format for submitting yearly catches to NAMMCO, and that the group report back to the Secretariat as soon as possible.

## FUTURE WORK PLANS

The **SC recommends** that the following Working Groups meet before its next meeting, noting that other meetings may be held depending on new requests received from the Council:

### Coastal Seal Working Group

Noting the closed and pending requests R.2.4.2 and R.2.5.2 from 2002 and 2007, the **SC recommends** that a WG on coastal seals be held to review the ***Norwegian*** management plan for grey and harbour seals, to perform assessments for grey and harbour seals in all areas, and to develop a common management model for both species in all areas. The WG should also consider whether the age data from the catch of grey and harbour seals in ***Iceland*** would improve the assessment. A meeting is planned for early 2011, and another meeting is likely required to fulfil the task. (Convenor: Tore Haug; Chair: Kjell Tormod Nilssen.)

**Working Group for Planning Future Surveys**
Noting that 2013 may be the best option for the next coordinated surveys, the **SC recommends** that a WG on the planning of future surveys be held between December 2010 and January 2011. Terms of reference should be to coordinate the year of the surveys, the time of year, and methods. (Chair: Geneviève Desportes.)

**WG on abundance estimates**
The **SC recommended** that an extra meeting on abundance estimates be held late 2010 or early 2011 to finalize not yet accepted estimates. This meeting could be combined with the meeting of the WG on Planning Future Surveys or held as a telephone meeting if appropriate. (Convenor: Geneviève Desportes; Chair: Daniel Pike.)

**WG on Large Whale Assessment**
Noting the recommended future work on the assessment and advice for Central North Atlantic fin and minke whales, the **SC recommends** an extra meeting on large whale assessment to be held between January and March 2011. (Convenor: Gísli Víkingsson; Chair: Lars Walløe.)

Two Working Group meetings are planned after the next SC meeting:

**Harbour Porpoise Working Group**
Noting the open request R.3.10.1 the **SC recommends** that assessments of harbour porpoise be carried out for all areas if possible. The WG is planned to meet between fall 2011 and spring 2012. (Chair: Droplaug Ólafsdóttir.)

**Narwhal and Beluga Joint Working Group**
The **SC recommends** that a new JWG meeting be held to update assessments and advice for beluga and narwhal. The final timing of this meeting is left for the two parties –***Greenland*** and Canada - to decide. (Convenor: Mads Peter Heide-Jørgensen; Chair: Rod Hobbs.)

**FINAL COMMENTS**

The video-conference venue for the SC meeting worked surprisingly well this year. A discussion on the possibility of having regular video-conference SC meetings instead of some of the face-to-face meetings will be taken at next year’s meeting. The **SC agrees** that its next meeting should be on the ***Faroe Islands***, with tentative dates set as 4-8 April 2011.

# MAIN REPORT
## Video-conference between Tromsø-Nuuk-Tórshavn, 21-23 April
## Start 21 April 12:00 Tromsø time

## 1. CHAIRMAN'S WELCOME AND OPENING REMARKS

Scientific Committee (SC) Chair Witting welcomed the Delegates (Section 5.4) to this first annual meeting in cyberspace facilitated by the eruption of the Icelandic volcano Eyjafjallajökull. He expressed his concerns about the last minute change of venue, but also his pleasure at seeing that so many SC members managed to participate in one way or another. He also expressed his regrets that some of the members and observers who did not manage to attend the meeting, either in person or via video-conference. Witting mentioned that the efforts he made to make this meeting the first one where the chairs' summaries were supplied in advance did not succeed, and was disappointed that many of these were not yet available at the start of the meeting.

## 2. ADOPTION OF AGENDA

Witting drew the Delegates' attention to the changes from the structure of last year's agenda and especially on the fact that each species' section contained now only two sub-sections ("Update" and "Future work") if there had been no Working Group (WG) meeting dealing with the species. He also noted that the complete lists of requests for advice, under this new agenda structure (Appendix 1), were now to be reviewed and discussed under "Future work plans". These changes made the agenda similar to the structure it had 3 years ago.

## 3. APPOINTMENT OF RAPPORTEUR

Scientific Secretary Acquarone was appointed rapporteur with the help of all the Delegates. Witting reminded the presenters to timely send all material to the rapporteur.

## 4. REVIEW OF AVAILABLE DOCUMENTS AND REPORTS

The documents available to the meeting are listed in Appendix 2.

### 4.1 National Progress Reports

The National Progress Reports (NPR) for 2009 from the Faroe Islands, Greenland, Iceland (draft) and Norway were presented to the SC. In addition, the SC was pleased to receive progress reports from Canada, Japan and the Russian Federation.

### 4.2 Working Group Reports

Reports of four NAMMCO WG were available at the meeting:

- WG on Abundance Estimates (Annex 1).
- WG on Walrus (Annex 2).
- WG on Marine Mammals and Fisheries Interactions (Annex 3).
- WG on Assessment (Annex 4).

In addition two other WG reports were available:

- ICES Study Group for By-catch of Protected Species (SGBYC) from its meeting in 2009.
- ICES/NAFO WG on Harp and Hooded Seals (WGHARP).

All these reports were discussed under the relevant agenda items.

### 4.3 Other reports and documents

Several other reports and documents were presented to the meeting, and were examined under the relevant items.

## 5. COOPERATION WITH OTHER ORGANISATIONS

### 5.1 IWC

Both Scientific Secretary Acquarone and General Secretary Lockyer attended the 61st IWC SC meeting, Madeira, Portugal, 31st May –26th June 2009, as observers. The main discussions of relevance to NAMMCO included the following.

**MSY rates under RMP** – There was agreement on a list of values for $r_{max}$ but there could not be complete discussions on amendments to the *CLA* (Catch Limit Algorithm) until the range for MSYR in the RMP is finalised.

**Implementation of the RMP for North Atlantic fin whales** – The main conclusion was that there were no new abundance estimates adopted for fin whales and there was agreement that final estimates need to be assembled and provided for consideration at next year's meeting (2010). It was also agreed that if the RMP is implemented, most variants (see IWC/61/Rep 1 for definitions of *Management Areas* for each variant**)** can be implemented without an associated research programme, the exception being variant 2.

**Implementation review for North Atlantic minke whales** – It was recommended that the estimate of abundance for the Eastern *Medium Area* of 81,000 (CV 0.23) for 2002-2007 be adopted for use in the *CLA*. It was furthermore agreed that the *Implementation Review* for the North Atlantic minke whales is now complete.

**Sex ratio methods for assessment of common minke whales off West Greenland** – It was noted that sufficient progress had now been made to overcome the technical difficulties related to the specification and implementation of sex ratio-based methods of assessment, and it was agreed that the method is ready to be evaluated using simulation testing.

**The Greenlandic need statement** – is expressed in terms of tonnes, not numbers of animals. Two approaches to the conversion of tonnage to numbers and *vice versa* were considered, but both contained uncertainty. The Committee agreed that for it to be able to adequately address the question and to determine a conversion rate per strike, it would require reliable, representative data from the Greenlandic hunt, involving data on the measured weight of obtained edible products from an adequate sample of animals of each species.

**Common minke whales off West Greenland** – Owing to a lack of data, the IWC SC has never been in a position to provide a satisfactory management advice for minke whales off West Greenland. This year, however, a new estimate of 17,307 (95% CI, 7,628 to 39,270) minke whales off West Greenland was adopted, and the IWC SC agreed to apply the method for interim management advice that was adopted and confirmed by the Commission in 2008. The IWC SC agreed that an annual strike limit of 178 will not harm the stock.

**Progress in the Development of Ecosystem Models** – Two approaches applied to the North Atlantic and reviewed by Corkeron (2008) were considered. One examined interactions between 3 fish species and common minke whales (Schweder, 2006; Schweder *et al.*, 1998; Schweder *et al.*, 2000) and another focused on interactions within and between the 3 fish populations, fisheries and climate. Corkeron (2008) commented that current problems with a cetacean-focused top-down approach might be resolved by applying new, broader modelling frameworks based on bottom-up processes. It was noted that the NAMMCO Scientific Committee proposed applying and comparing 4 different modelling approaches in the Northeast Atlantic.

### 5.2 ASCOBANS

No new information relevant to NAMMCO.

### 5.3 ICES & NAFO

The ICES Working Group on Marine Mammal Ecology (WGMME) met 2-6 February 2009 at the Instituto Español de Oceanografía in Vigo, Spain. The WG considered a wide range of issues, including: reviewing various aspects of OSPAR's EcoQOs for seals, management procedures for estimating by-catch limits for small cetaceans, assessing population and stock structure in small cetaceans, suggesting recommendations for improvements in the procedure for reporting on Favourable Conservation status (FCS) under the EU Habitats Directive, and developing a framework for monitoring and surveillance of European marine mammal populations.

A review of the ASCOBANS/HELCOM Working Group report on common dolphin population structure in the Northeast Atlantic, and available information on population structure in harbour porpoise in the Northeast Atlantic, was carried out. The WGMME concurred with the ASCOBANS/HELCOM recommendation that only one common dolphin population inhabits the Northeast Atlantic, although the distributional range of the population is unknown, as sampling of individuals for genetic analysis was confined to continental shelf and slope waters and oceanic waters of the Bay of Biscay. A separate Iberian harbour porpoise population has recently been identified using genetic analysis, and the WGMME strongly recommended that this population should be given a high priority for conservation, as a consequence of its presumed small population size, low genetic diversity and likely susceptibility to habitat degradation. The WGMME also strongly recommended immediate action by the Spanish and

Portuguese governments in monitoring and conserving the Iberian harbour porpoise population.

New data from the SCANS II and CODA projects were reviewed, and WGMME concurs with the recommendation to use the CLA approach for estimating by-catch limits for small cetaceans. Given the nature of the data available, WGMME believes it is appropriate to use the most conservative measure (*i.e.* in a worst-case situation) for both harbour porpoises and common dolphins in the Northeast Atlantic. It was noted by the WG that the continuation, and establishment in some cases, of national observer by-catch programmes is extremely important, in order to obtain current estimates of incidental capture for all marine mammal species. Furthermore, the by-catch management procedures developed under SCANS-II and CODA projects should be taken into consideration by DG MARE when reviewing the EU Regulation 812/2004. The WG also noted the need for the continuation of surveys of the type of SCANS II and CODA to estimate absolute abundance, at least every 5 years.

Initial development of a European framework for surveillance and monitoring of marine mammals was undertaken, and the WG noted that, while it seems clear that monitoring of abundance, by-catch and health status (through stranding programmes) may reasonably form the core of surveillance for cetaceans, the importance of other types of information (*e.g.* life-history data) and monitoring of specific threats (*e.g.* offshore construction) should also be recognised when designing a surveillance strategy. Further, monitoring programme design should take account of new findings on the stock structure, for example the identification of an isolated Iberian stock for harbour porpoise.

**ICES WGHARP**

The ICES/NAFO Working Group on Harp and Hooded Seals (WGHARP) met during 24-27 August 2009 at the ICES Directorate in Copenhagen, Denmark to consider recent research and to provide catch advice on the Northeastern Atlantic Ocean stocks of harp seals. The WG received presentations related to catch (mortality) estimates, abundance estimates, and biological parameters of White Sea/Barents Sea and Greenland Sea harp seal stocks, and provided updated catch options in response to a 2008 request from Norway. The WG also received and reviewed information on the Northwest Atlantic harp seal stock, as well as the Northwest Atlantic and Greenland Sea hooded seal stocks. The WG also provided catch advice for the latter stock.

**ICES ASC**

The 2009 ICES Annual Science Conference (ASC) was held in Berlin, Germany, 21-25 September 2009. The conference included no particular theme session devoted to marine mammals. Nevertheless, some sessions were designed with marine mammals included as an integral part. Relevant sessions at the 2009 ASC were:

- Theme session C: “Advances in marine ecosystem research: what we have learnt from GLOBEC and what we can carry forwards in future climate related programmes”.
- Theme session G: “Comparative study of climate impact on coastal and continental shelf ecosystems in the ICES area: assessment and management”.

- In theme session K ("Habitat science to support stock assessment"), results were presented from the Norwegian ecosystem surveys where also marine mammal observations are an integral part.
- Theme session M: "Avoidance of by-catch and discards: technical measures, projects, and state of data".
- Theme session P: "Ecological food web and network analysis: a tool for ecosystem based management?"

Upcoming theme sessions, relevant to marine mammal issues, intended for the ASC, 20-24 September 2010 in Nantes, France, include titles such as "Natural mortality variation in populations and communities", "Monitoring biological effects and contaminants in the marine environment: where do we go from here?", "Beyond correlations: what are suitable methods for describing and testing non-linear spatio-temporal changes, patterns and relationships?" and "Marine Biodiversity – the science and management needed to meet 2010 commitments"**.** More information is available at www.ices.dk.

**ICES By-catch Working Group**

Ólafsdóttir mentioned that cooperation with ICES has been established regarding a Workshop on By-catch Monitoring which will be discussed under item 7.1.

Ólafsdóttir then reported (SC/17/O-12) that the ICES Study Group for By-catch of Protected Species (SGBYC) met in Copenhagen 1-4 February 2010. The SG examined the monitoring, assessment and mitigation of the incidental capture of protected species. It also reviewed annual national reports submitted to the European Commission under Regulation 812/2004, collated by-catch estimates and reviewed mandatory and pilot projects and scientific studies carried out under this regulation.

### 5.4 JCNB

The Canada/Greenland Joint Commission for the Conservation of Narwhal and Beluga (JCNB) meet in Nuuk, May 2009. The NAMMCO Secretariat was invited to observe, but was not able to attend. Ugarte was present in the meeting, as part of the Greenland delegation. The report of the Joint NAMMCO/JCNB Scientific working group was reviewed and accepted, and management advice in accordance with the scientific recommendations was provided.

## 6. ROLE OF MARINE MAMMALS IN THE MARINE ECOSYSTEM

### 6.1 Update from MMFI WG

Acquarone presented document SC/17/19. In October 2009 NAMMCO filed an application for funding at the Nordic Council of Ministers which was aimed at creating a network of scientists for writing up the project defined by the WG on Marine Mammals and Fisheries Interactions at its meeting in 2009 and recommended by Council (NAMMCO 2010a). This application proved successful and this document is the report of the kick-off meeting which defined the practical details of the organisation for writing up the project proposal. This network is coordinated by Matís in Iceland on behalf of NAMMCO. Matís will not take part in the actual modelling project.

The WG on Marine Mammal Fisheries Interactions met in Copenhagen March 13-14 to compile proposals and budgets for the ecosystem modelling of the Barents' Sea and Icelandic Waters. Details on the meeting can be found in the WG report (Annex 3).

The WG tasked Walløe and Butterworth to take charge of the overall project coordination, with the main coordinating task being to

- Ensure that the answers from the models are comparable
- Moderate the run of the models to be as simple as possible in the first place
- Employ more complex refinements
- Adjust the dynamic schedule for the meetings, deliverables and deadlines
- Liaise with the Data Officers.

The **SC concludes** that there is sufficient basis for proceeding with the planned modelling for both areas and that funding applications should include both the Barents Sea and Icelandic water areas. In particular it noted that obtaining adequate input data for the Ecopath with Ecosim (EwE) approach may be more challenging than for the other approaches as EwE necessarily includes lower trophic levels. The **SC agrees** that funding should be sought from sources and in the following order of priority: 1. Nordic Council Ministers, 2. European Union, and 3. Norwegian sources.

The **SC notes** that the project is proceeding and **strongly recommends** its continuation. At the same time, the **SC notes** that the steering group of this independent research project will report to the NAMMCO SC, **recognising** that the steering group need no input from the SC.

### 6.2 Other updates

Haug reported that in previous studies of Barents Sea harp seals, observations have indicated that poor condition of juvenile and adult seals could be linked to reduced recruitment to the stock. Data collected during April/May in 1992-2001 and 2006 on-board Norwegian sealers in the Southeastern Barents Sea (the East Ice) have revealed that for adult seals, a significant drop in body weight, condition index, and blubber thickness occurred in 2006 compared to 1992-2001. Updated information is necessary to assess whether this drop in condition is still prevailing and can be linked to observed reduction in recruitment after 2003.

Lockyer reported about the upcoming International Conference by the title "Marine Ecosystem Management – How to make it sustainable?" to be held in Ilulissat 26-27 May 2010. The event is abundantly sponsored by the Nordic Council of Ministers. Lockyer explained that NAMMCO received a request to participate in the planning of this conference and has actively contributed in defining the programme. Lockyer and Ugarte are among the speakers in one of the four sessions: Ecology of the North Atlantic; Policy-making in marine ecosystem management; Implementation of socioeconomic considerations in sustainable management of the marine ecosystem; Ethics in sustainable management of the marine ecosystem –cultural and environmental aspects. (**Note:** this conference was subsequently cancelled at short notice in mid-May.)

### 6.3 Future work

Future work is focused on the modelling exercise described in item 6.1.

## 7. BY-CATCH OF MARINE MAMMALS

### 7.1 Updates

**<u>ICES-NAMMCO workshop on Observation Schemes for By-catch of Mammals and Birds</u>**

A proposal from NAMMCO to organise a joint NAMMCO/ICES workshop on by-catch monitoring, both using observer schemes and alternative methods, was approved by ICES in 2009, with the joint workshop being convened in late June 2010. The Terms of Reference are to 1) review and describe the advantages and disadvantages of existing observation schemes for marine mammals and seabirds and to 2) recommend best practice when establishing and implementing by-catch observation schemes. A draft agenda was available to the SC (SC/17/O-16), and the workshop aims to provide a first step in developing a training manual for protected species by-catch monitoring.

The **SC notes** that Ólafsdóttir and Lockyer are in the steering group of the workshop to which there have been 30 potential invited participants (of which realistically 20-25 are expected to attend). The main speakers have been invited based on the quality of their expertise to stimulate discussions for a manual on best practices. Of the invited participants 3 are fully taken charge of by NAMMCO and one is refunded for expenses as the person is a local resident.

At its 2008 meeting, the **SC strongly recommended** that the Norwegian analysis of by-catch and the evaluation of the new monitoring system be completed as soon as possible and presented to the SC at its next meeting. Haug reported that preliminary analyses have been done on the raw data from 2006 to 2008. Bjørge is scheduled to present final results at the Joint NAMMCO/ICES workshop on by-catch monitoring to be held this summer in Copenhagen. The **SC reminds** the Norwegian SC members that this workshop was meant to evaluate the Norwegian by-catch reporting system and **strongly recommends** them to ensure completion of the evaluation in order for it to be ready for presentation at the workshop.

The **SC looks forward** to the results of the joint workshop, and the report which is planned for publication next autumn and **notes** that from NAMMCO countries only Iceland (Ólafsdóttir) and Norway (Bjørge) are represented at the workshop.

**<u>Marine mammal by-catch monitoring</u>**

***Iceland***

Ólafsdóttir presented a report (SC/17/16) containing new information on the monitoring of marine mammal by-catch in Icelandic fisheries in 2009 and a review from previous years**.** Information on by-catch and fishing effort was obtained from gill-net research surveys (April), a Fishery Directorate observer programme (April-December), lumpsucker fishery logbooks and reports from lumpsucker fishermen. Information on by-catch events were also obtained from anecdotal sources, skin trading reports and lists of collected research samples. A total of 266 by-caught marine mammals were reported in 2009 (Table 1). All reported by-catch was from gill-nets and no marine mammal entanglements were reported in other fisheries.

No by-catch has been reported in logbooks for fisheries other than lumpsucker fisheries since mid year 2008 when a new system of electronic logbooks was implemented. Technical difficulties with the new system have caused lack of reporting and a revised version of the system where reporting of marine mammals and birds is facilitated is underway.

Four marine mammal species were observed entangled in the lumpsucker fishery in 2009. Information from 215 fishing trips showed marine mammal by-catch in about a third of the trips and gave strong indications of relatively high by-catch rates of some marine mammal species in the lumpsucker fishery in Iceland.

A total number of 374 (95% CI: 41 to 560) harbour porpoises was estimated caught in the cod gill-net fishery in March and April using by-catch data from fishery research surveys. Low by-catch rates of other species and insufficient effort data from the lumpsucker fisheries prevent estimations of total by-catch numbers for other groups.

| **Species** | **Latin name** | **Fishing gear** | **Reported** |
|---|---|---|---|
| Harbour porpoise | *Phocoena phocoena* | Gill-net | 16* |
| Harbour porpoise | *Phocoena phocoena* | Lumpsucker gill-net | 34 |
| Bearded seal | *Erignathus barbatus* | Gill-net | 1 |
| Grey seal | *Halichoerus grypus* | Lumpsucker gill-net | 26 |
| Harbour seal | *Phoca vitulina* | Gill-net | 3 |
| Harbour seal | *Phoca vitulina* | Lumpsucker gill-net | 94 |
| Harp seal | *Pagophilus groenlandicus* | Gill-net | 23 |
| Harp seal | *Pagophilus groenlandicus* | Lumpsucker gill-net | 34 |
| Unidentified seal | | Lumpsucker gill-net | 35 |
| Marine mammal total | | | 266 |

**Table 1.** Marine mammal by-catch reported in Icelandic fisheries in 2009. * Total estimated by-catch in March and April was 374 (95% CI: 41 to 560).

***Faroe Islands***

Mikkelsen reported that reporting by-catch of marine mammals is not at present mandatory in the Faroe Islands. A new electronic logbook system for all vessels larger than 15 BRT is under development, and is planned to be enforced in 2011. The Ministry of Fisheries has secured that by-catch reporting is mandatory and implemented in the new system. By-catches of large whales have traditionally been reported directly to the Museum.

The **SC supports** the effort of Iceland in obtaining by-catch data. It **recommends** that other countries strengthen their efforts towards establishing and implementing by-catch monitoring systems so that total by-catch can be estimated. More detailed data than those presented here by Iceland is needed for this. Like last year, the **SC notes** that some by-catch may be reported as directed catches, as in the case of Greenland. It **reiterates** its recommendation that Greenland evaluate the degree to which by-catch is actually being reported as catch.

The SC mentioned that there are indications that seals can escape certain types of nets by ripping holes through them in case of entanglement. This behaviour could be utilised in future mitigation methods. It was also noted that species identification by fishermen presents problems in monitoring systems based on logbooks and other self reporting systems for by-catch. Standardised guidelines for fishermen may reduce this problem.

## 8. SEALS AND WALRUSES STOCKS - STATUS AND ADVICE TO THE COUNCIL

### 8.1 Harp Seals

#### 8.1.1 Update

The ICES/NAFO Working Group on Harp and Hooded Seals (WGHARP) met during 24-27 August 2009 at the ICES Directorate in Copenhagen, Denmark to consider recent research and to provide catch advice on the White Sea/Barents Sea and Greenland Sea stocks of harp seals (SC/17/O11).

***White Sea/Barents Sea***

A Russian survey of the White Sea/Barents Sea harp seal stock were conducted during 14-16 March 2009, and resulted in an estimate of 157,000 pups (95% CI, 123,680 to 190,320). This estimate is significantly lower than the estimates produced prior to 2004. WGHARP concluded that the survey appeared to have been carried out very well as there were improvements in the reconnaissance efforts, evaluation of whelping, and survey timing (*i.e.* closely approximating the dates of surveys flown during 1998-2003). Hypotheses which remain for explaining the reduced pup production since 2004 include reduced adult recruitment due to past juvenile mortality, unobserved mortality of adults in recent years, or a shift in contemporary pupping to areas outside of the traditional areas. The high quality of the survey and the availability of recent data on reproductive parameters led the WG to conclude that the stock can now be considered data-rich. However, the precipitous decline in pup production after 2003 could not be accounted for by the existing population model, and as a result the model greatly over-predicted pup production. The model did provide an approximate multiplier that could be used to scale the pup production in order to obtain an approximate population size. Using a multiplier of 7, a population estimate of 1,099,000 was obtained. The model was also considered inappropriate to provide catch options. The only alternative available was to provide sustainable catch options based upon the Potential Biological Removal (PBR) approach. Using this approach, WGHARP estimated that the TAC for the White Sea/Barents Sea harp seal stock should be 30,062 animals.

Haug further informed that a workshop to compare methods of reading aerial photos from harp seal pup surveys had been held on 25-29 May 2009 at PINRO in Murmansk. Readers from IMR and PINRO exchanged photos and used their own methods on the other group's photos. It was concluded that both groups appear to have satisfactory, and comparable, methodologies for analyzing the aerial photos.

A Joint Norwegian-Russian Research Programme on Harp Seal Ecology was initiated to assess the ecological role of harp seals by estimation of the relative contribution of various prey items to their total food consumption. One of the aims of the programme is to assess the spatial distribution of harp seals throughout the year by conducting experiments with satellite-based tags and marking of animals in the White Sea. The programme was supported by the NAMMCO SC in 2006 and 2008, and 2009. However, although part of the programme is in progress (ecosystem surveys and abundance estimation), the core activities of the programme have not yet been properly started. The reason for this being that Russian authorities (the Federal Technical Committee, FTC) refused to permit deployment of satellite tags on harp seals in the White Sea in May in 2007, 2008 and 2009. At its 2008 and 2009 meeting, the **SC strongly regretted** the decision made by the Russian FTC to refuse the deployment of satellite tags on harp seals in the White Sea in May, and recommended that Russia permits Norwegian and Russian scientists to conduct this important tagging according to the original plans (NAMMCO 2009a p.123 and 2010b p.253). The tagging component of the study includes 15 deployments of satellite tags on harp seals in the Norwegian zone of the Barents Sea in 2010. For 2011, a total of 15 tags are planned for deployment in the White Sea zone. A request for a support to this programme was forwarded to the Council of NAMMCO in 2008 and 2009. In 2008 the Council supported the request from the SC and encouraged the Russian authorities to allow the deployment of satellite tags in the White and Barents Sea (NAMMCO 2009b p.19) and the Management Committee for Seal and Walruses agreed to send a recommendation to the Russian authorities (NAMMCO 2009b p. 92). In 2009 the Management Committee for Seals and Walrus asked the Russian Federation for advice on how to follow up a request to Russia concerning permissions (NAMMCO 2010c, p.111). The **SC urges** the Council to address directly this recommendation to the Russian authorities as soon as possible to facilitate tagging of harp seals in the White Sea in 2011.

***Greenland Sea***

With respect to the Greenland Sea harp seal stock, new data were collected in 2009 on reproductive rates to supplement the Norwegian survey of pup production carried out during March-April 2007 (110,530 pups; 95% CI: 56,080-164,580). Because these new data are available, WGHARP considers the stock to be data-rich. Therefore, it is appropriate to use a population model to estimate abundance and evaluate catch options. Incorporating the recent survey estimates and reproductive data into the population model used previously produced a population estimate of 810,600 (95% CI: 487,100-1,134,000) animals for 2009. Using this model, WGHARP suggests that a sustainable catch level would be 30,865 1+ animals, or an equivalent number of pups (where one 1+ seal is balanced by 2 pups) in 2010 and subsequent years.

Greenland Sea harp seals are currently classified as data-rich. An implication is that ICES now find the Precautionary Approach framework developed for the management of harp and hooded seals appropriate for this particular population, given that the reference levels reflect the most recent estimate of total population size which is the largest observed to date. ICES suggest that when the population is between $N_{70}$ and $N_{max}$, harvest levels may be decided that may stabilise, reduce or increase the population, so long as the population remains above the $N_{70}$ level (*i.e.* 70% of $N_{max}$). A preferred option is to design the TAC to satisfy a specific risk criterion (*e.g.* 80% probability of remaining above $N_{70}$ over a 10-year period). Using this approach, a modelled catch level of 42,400 1+ animals, or an equivalent number of pups (where one 1+ seal is balanced by 2 pups), in 2010 and subsequent years is obtained. Any allowable catch should be contingent on an adequate monitoring scheme to detect adverse impacts before it is too late for them to be reversed, particularly if the TAC is set at a level where a decline is expected.

A concentration of about 1,000 harp seal pups (white coats) arriving in Southwest Greenland with the drift ice from the east coast was documented in 2007 (Rosing-Asvid 2008). Pups have arrived in Southwest Greenland every year since then. This year (2010) the first pups were seen on March 26 and mother-pup pairs have been observed. The timing of the birth of these pups indicates that they belong to the Greenland Sea stock. It is unknown how many seals are born in Southeast /Southwest Greenland far from the traditional breeding area.

***Northwest Atlantic***

Haug presented new information on Northwest Atlantic harp seals (SC/17/O10, SC/17/O14, SC/17/O15). After a period of high catch levels in 1996-2006 (average 272,600 per year), Canadian catches declined due to ice conditions and poor markets, reaching a low of approximately 72,000 in 2009. Since 1980, Greenlandic catches increased relatively steadily to a peak of approximately 100,000 in 2000, but thereafter they have varied slightly and averaged a little over 80,000. Photographic and visual aerial surveys to determine current pup production of Northwest Atlantic harp seals were conducted off Newfoundland and in the Gulf of St. Lawrence during March 2008. Using the photographic estimate resulted in an estimate of total pup production in 2008 of 1,648,800 (SE:118,000; CV:7.2%); using the visual estimate resulted in an estimate pup production of 1,076,600 (SE:61,300; CV:5.7%). Despite the obvious uncertainties connected with the observed differences between survey results, both estimates indicate that 2008 pup production is similar to, or higher than, that seen over the past decade. A population model was used to examine changes in the size of the Northwest Atlantic harp seal population between 1952 and 2009. Fitting the model to the low estimates of 2008 pup production resulted in an estimated total population size of 6,851,600 (95% CI: 5,978,500-7,697,200). When the data were fitted to the high 2008 survey estimate, the estimated total population increased to 8,238,500 (95% CI: 6,774,300-9,540,300).

### 8.1.2 Future work

The **SC notes** that $N_{max}$ is not a biological parameter in the management models of the WGHARP, and it **recommends** that a discussion on how $N_{max}$ is estimated for the different seals stocks be taken by the WGHARP. It encouraged the NAMMCO SC members who participate in the meetings to ensure that the discussion is taken.

**SC has recommended** flying reconnaissance surveys to investigate the possible presence of whelping patches in untraditional areas, both in the Greenland Sea (*e.g.* south of 67°N in East Greenland), the Denmark Strait and Southwest Greenland, and in the Barents Sea (southeast and north). Such surveys have been proposed in Norway and Greenland but they have so far not received funding. It also **recommends** continuing the sampling of biological parameters, and the characterization of stock identity.

**New request 2.1.11:** *The Scientific Committee is requested to evaluate how a projected increase in the total population of Northwest Atlantic harp seals might affect the proportion of animals summering in Greenland.* As the NAMMCO SC has no tradition of establishing WGs on harp seals, the **SC recommended** that Greenland forward the request to ICES/NAFO so that it can be considered by the WGHARP.

## 8.2 Hooded seals

### 8.2.1 Update

***Greenland Sea***

Haug reported that from 14 March to 3 April 2007, aerial surveys were carried out in the Greenland Sea pack-ice (the West Ice) to assess pup production for populations of both hooded and harp seals (SC/17/O6). All data are now analyzed, and the total estimate of hooded seal pup production was 16,140 (95% CI: 11,950- 20,380).

Haug further informed that 396 bluebacks were taken for scientific purposes in 2009 to continue a time series, started in 1995, where condition of bluebacks (weights, measurements, blubber thickness) was measured at fixed time windows during the Greenland Sea hunt. In 2007-2008, materials for a project on the evaluation of reproduction, contaminant loads and general health status of Greenland Sea hooded seals were collected, and the project is presently being evaluated for funding by the Norwegian Research Council. Further sampling will be conducted in July 2010 when a minimum of 200 adult hooded seals will be collected.

No assessment was performed for hooded seals at the WGHARP meeting in 2009. The next meeting is scheduled for the coming year and there are no outstanding requests from previous years. There will be some work to improve the models regarding reproductive parameters.

***Northwest Atlantic***

Analyses of telemetry data from hooded seals tagged off Southeast Greenland have given a detailed description of the seasonal distribution of hooded seals from the West Atlantic population (Andersen *et al.* 2009). The young hooded seals come to Southeast Greenland during their first spring/summer and they normally stay in the area during the first years of their life. Young hooded seals equipped with data-loggers that collected depth and temperature have been able to sample a year-cycle of temperature data in various depths along the Southeast Greenland coast. These data have been used in a study that indicates a strong influence of the ocean on the glaciers in Southeast Greenland. The data-set is unique as it provides data in all kind of weather in an area with dense drifting ice. Oceanographers are paying for a continuation of the study to monitor temperatures and salinity of the seawater along the southeast Greenland coast, and this will give a time-series on movements of young hooded seals in the area.

#### 8.2.2 Future work

Tagging in connection with oceanography research will continue. In 2010 tags have been put on pups in Newfoundland.

The **SC strongly recommends** facilitating the funding and execution of a) Norwegian reconnaissance surveys for relocated pupping areas of hooded seals in the Greenland Sea and b) a Norwegian health project that aims to identify biological factors that contribute to the prevailing low abundance of hooded seals in the Greenland Sea.

### 8.3 Ringed seal

#### 8.3.1 Update

No updates were available.

#### 8.3.2 Future work

Greenland will instrument ringed seals with CTD-tags in the Ilulissat Icefjord in 2010. They have funding application for aerial surveys and instrumentation of ringed seals in the Baffin Bay in view of oil prospecting, and perform opportunistic sampling of biological material from ringed seals for genetic analysis in relation to polar bear surveys.

The **SC is pleased** to see that new projects have been initiated and **reiterates** its previous recommendations to perform abundance estimates on the sea ice in offshore areas. It also recommends obtaining new abundance estimates and increasing the effort in tagging for the better understanding of stock structure.

### 8.4 Grey seal

#### 8.4.1 Update

***Greenland***

An adult grey seal was seen and photographed in South Greenland in 2009 (Rosing-Asvid 2010 *in press*), as the first confirmed sighting of grey seals in Greenland. The **SC notes** this interesting information and **recommends** that Greenland gather further information on the presence of grey seals during fieldwork on harbour seals. Given the possibility of a small isolated stock of grey seals in Southeast Greenland, the **SC recommends** that grey seals be protected against hunting in Greenland.

***Norway***

The new Norwegian management plan for coastal seals has in part been implemented and population modelling efforts are being programmed for grey seals. Reproductive data to be used in the model are being collected from the catches. The **SC reiterates** its recommendation from last year that the Russian grey seal breeding colonies on the coast of Murmansk be surveyed again.

***Faroe Islands***

No progress has been made on the estimation of population size and level of removals. In particular there is no compulsory reporting of the removals in connection to fish farming. Monitoring of the removals has been assigned to the Ministry of Fisheries, and an abundance survey is planned for the coming autumn.

The **SC reiterates its strong recommendation** that all efforts be made in providing a proper estimate of population size and catch for its next meeting.

***Iceland***

A survey carried out in the autumn of 2009 indicated that grey seals pup production was somewhat lower than estimated in 2008. Direct takes have decreased in recent years (around 45 animals in 2009), making by-catch the likely main removal method. However, no reliable estimate of total by-catch is available.

#### 8.4.2 Future work

The **SC strongly recommends** that all directed catches and by-catch are reported.

The **SC reiterates its recommendation** to hold a Working Group meeting on coastal seals by early 2011. It **recommends** that the **terms of reference** will be to perform a thorough review of the Norwegian management plan and to perform an assessment of grey seal stocks throughout the North Atlantic (in accordance with request 2.4.2). In case data are inadequate the WG should make recommendations on further research needed in order to secure adequate data for an assessment, and it is **recommended** that the WG aim at a single management model for all coastal seals in NAMMCO regions. The WG should also consider whether the age data from the catch of grey and harbour seals in Iceland would improve an assessment.

### 8.5 Harbour seal

#### 8.5.1 Update

***Greenland***

A small colony of about 40 adult harbour seals was found in southeast Greenland in 2009. Eight of these seals were caught alive (early September 2009) and equipped with satellite-linked transmitters. The study is still ongoing and the seals have stayed close to the island where they were found (mainly within a range of 10 km) and only two seals have so far made excursions more than 50 km from the colony. The **SC welcomes** this information and **recommends** the continuation of the study.

A draft of the new hunting regulation had been sent for hearing, but no new regulation is in force. Harbour seals have disappeared or have become very rare all along the West Greenland coast and the **SC reiterates** its recommendation of a total ban of the hunt for harbour seals in Greenland.

***Norway***

Aerial surveys are planned for 2011 and 2012, and the species is included in a larger ecosystem project of the two Norwegian fjords Porsanger and Hardanger.

***Iceland***

The last overall survey on the species was in 2006. There are annual counts by the Seal Centre in Northern Iceland in a small high density area, with the last count being around 1,000.

#### 8.5.2 Future work

The **SC reiterates its recommendation** that a formal assessment of harbour seals in all areas (R.2.5.2) be carried out by a WG meeting on coastal seals in 2011 (see also 8.4.2).

### 8.6 Bearded seal

#### 8.6.1 Update

One bearded seal was instrumented with a satellite transmitter in summer 2009 in the area around Cape Farewell, Greenland. The tag is still functioning revealing that the animal has not moved from the area and has resided mainly in a 5 km radius from the tagging location.

#### 8.6.2 Future work

There are plans on tagging more animals in the Cape Farewell area during summer 2010, and Greenland is applying for funding for acoustic monitoring and tagging in connection with Oil exploration in Baffin Bay.

**Noting** that only a few studies have been initiated for this data-poor exploited species, the **SC reiterates** the recommendation from last year to renew efforts towards information on biology, abundance and stock status in view of an assessment.

### 8.7 Walrus

#### 8.7.1 WG Report

The WG on walrus met in Copenhagen, 23-26 November 2009 (Annex 2). The report from the meeting was approved inter-sessionally by the SC and presented to Council (Annex 5). For this reason it was not discussed again at this meeting.

#### 8.7.2 Other updates

A volume of the NAMMCO SPS dedicated to walrus is presently being planned (see item 12 and SC/17/13).

#### 8.7.3 Future work

The GINR has planned a tagging and DNA-analysis study of walrus from Upernavik and Ummannaq in order to determine the stock origin of these animals. Funding for this work had not yet been granted. Additionally a “user’s knowledge” interview on walrus in West Greenland is planned for 2010.

The **SC notes** that the quotas for walrus for the West Greenland –Baffin Island stock follow the advice on sustainable removals, while the quota for the Baffin Bay stock (Northwest Greenland) is higher than the advice of sustainable removals (a preliminary 2010 quota of 75 animals compared with an advice of no more than 68 animals). The **SC recommends** that the total removals be smaller than or equal to the recommendation of total removals.

In 2009, following the recommendation of the SC (NAMMCO 2010b p. 280), the Management Committee for Seals and Walrus recommended that the Russian authorities facilitate the Joint Norwegian-Russian research programme on walrus and beluga ecology and agreed to send them recommendation on this issue (NAMMCO 2010a p.95). The **SC urges** the Council to address this recommendation to the Russian authorities as soon as possible.

## 9. CETACEANS STOCKS - STATUS AND ADVICE TO THE COUNCIL

### 9.1 Fin whale

**R.3.1.6:** The Council had requested the SC 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. The request was dealt with by the Large Whale Assessment WG.

The SC considered that implementation of the IWC RMP (IWC 1994a, b) to calculate catch limits provided an appropriate basis to address the Council's request. The RMP can be applied at a "*Small area*" level, or to combinations of such *Small areas*.

#### 9.1.1 WG reports (Abundance & Assessment)

***Abundance***

| **Survey Areas** | **West Greenland** | **Iceland Coastal** | **Iceland-Faroes** |
|---|---|---|---|
| | Aerial | aerial | shipboard |
| Fin whale | *4,359*<br>*(1,879-10,114) n* | - | 20,613<br>(14,819-25,466) n<br>26,117<br>(17,401-39,199) p |
| Minke whale | 16,609<br>(7,172-38,461) pa<br>22,952<br>(7,815-67,403) pa | 15,055<br>(6,357-27,278)<br>10,680<br>(5,873-17,121) | 10,782<br>4,733- 19,262)n |
| Humpback whale | 3,272<br>(1.230-8.710) pa | 1,242<br>(632-2,445) p | 11,572<br>(4,502-23,807) n |
| Pilot whale | **2,976**<br>**(1,178-7,515) n** | - | **Not accepted** |
| Sperm whale | - | - | To be done |
| Bottlenose whale | - | - | To be done |
| Harbour porpoise | **33,271**<br>**(15,939-69,450) pa** | To be done | - |
| White beaked dolphins | **9,827**<br>**(6,723-14,365) p** | To be done | To be done |

**Table 2.** T-NASS (2007) abundance estimates endorsed by the NAMMCO SC for assessment purposes. Estimates in bold are first estimates for the species in the area, estimates in *italic* have been endorsed but need further work. *Legend*: n, uncorrected for bias; p, corrected for perception bias; a, corrected for availability bias. Further work is needed before acceptance in a few cases, for detail of this see Table 5 (Item 11).

T-NASS estimates of fin whale abundance which have been endorsed for assessment purposes are shown in Table 2. Estimates for all areas except Norway have been provided to and reviewed.

The different North Atlantic surveys from 2007 as well as the mosaic Norwegian surveys are considered additive, with a point estimate of around 50,000 for the total number of fin whales in the North Atlantic.

***Assessment***

In its assessment of Central North Atlantic fin whales, the Large Whale Assessment WG considered the seven stock structure hypotheses that have been evaluated for plausibility both by NAMMCO and the IWC. Details on the assessment can be found in the WG report (Annex 4).

The **SC approves** the report of the WG and **recommends** that the operating models developed for the seven stock structure hypotheses by the IWC SC in the RMP testing process provide appropriate assessments for this resource to be used in the formulation of management advice.

***Management advice***

The Commission requested advice on the estimation of sustainable catch levels for fin whales in the Central North Atlantic. Since in practice such catches would take place in the West Iceland (WI) sub-area, the **SC considers** that recent implementation of variants of the IWC RMP to calculate strike limits restricted to this sub-area provided an appropriate basis to address the Commission's request.

The two relevant RMP variants consider either only the WI sub-area, or the combination of the WI and CG (East Greenland) sub-area, as the units for which a strike limit might be calculated. The IWC SC RMP trials also show that the latter choice 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, so the **SC considers** that this constituted an appropriate basis for a "safe" removal recommendation.

The RMP output depends on the chosen tuning level (TL). The IWC SC had recommended to their Commission, based on simulation trials that for single stocks with certain stock structure, that TL ranging from 60% to 72% were safe from a conservation perspective (IWC 1992). The IWC SC RMP implementation process had extended these trials to cover stock structure uncertainty for the 72% tuning. The RMP's output is a strike limit of 87 fin whales for the 72% tuning, and 154 for the 60% tuning; the latter output is close to the earlier recommendation of the NAMMCO SC that a total annual removal of 150 whales from this population would be sustainable (NAMMCO 2007).

The **SC considers** that an annual strike up to 154 fin whales from the WI Sub-area is sustainable at least for the immediate 5-year period. It **notes** that the RMP variant with a 60% TL has yet to be simulation tested for trials involving stock structure uncertainty in the long-term (*i.e.* RMP simulation framework timeline of 100 years). While simple extrapolation from the results of trials mentioned above suggests that catch levels for this tuning would be safe, the **SC recommends** that the simulation trials required to check this be carried out as soon as possible, with the recommendation regarding the long-term sustainable level of catch to be reconsidered in the light of these results.

#### 9.1.2 Other updates

There were no other updates.

#### 9.1.3 Future work

The **SC recommends** that the simulation trials required to check if catch levels for 60% tuning are safe should be carried out as soon as possible, and it approved the recommendations of the WG.

The **SC recommends** further studies to help distinguish between alternative stock structure hypotheses, particularly in and around the area of proposed whaling, using several different approaches *e.g.* genetics, satellite telemetry and photo-identification.

### 9.2 Humpback whale

**R.3.2.5:** A new Council request asked the SC to assess the sustainability of yearly catches of 5, 10 and 20 humpback whales off West Greenland. The request was dealt with at the Large Whale Assessment WG. It carried out an assessment and provided management advice by a management procedure that has been tested by the IWC SC on simulation trials for humpback whales off West Greenland.

#### 9.2.1 WG reports (Abundance & Assessment)

***Abundance***

T-NASS estimates of humpback whale abundance which have been endorsed for assessment purposes are shown in Table 2. Estimates from all areas except Norway have been provided to and reviewed. The possibility for responsive movement to survey vessels remains an important point to be investigated.

There was clearly a redistribution of sightings in the Icelandic-Faroese areas compared to previous surveys, possibly due to changes in the marine ecosystem.

The different North Atlantic surveys from 2007 as well as the mosaic Norwegian surveys are considered additive, except for addition between the Icelandic shipboard and aerial surveys. Adding the estimates from Iceland, the Faroe Islands, Greenland, and Canada results in a minimum of about 15,000 humpback whales in the North Atlantic, to which should be added the Northeast Atlantic and the US eastern seaboard.

***West Greenland***

***Stock structure***

The assessment and management advice is based on the assumption that humpback whales in West Greenland comprise a separate summer feeding aggregation that is best treated as a separate management unit (IWC 2002 and 2009). Most of the animals in this aggregation spend the winter breeding season in the West Indies together with individuals from other summer feeding aggregations in the North Atlantic.

This assumption is supported by satellite tracking of humpback whales in West Greenland in 2008 and 2009. A total of 34 satellite transmitters were deployed, with results showing strong affinity to certain coastal localities with a later dispersal offshore on the banks. The distribution of satellite tracked whales matches well with the areas covered by aerial surveys off West Greenland. One whale moved to the Labrador coast in August indicating affinity to the western part of the Atlantic. There was no additional new information on stock structure.

***Biological parameters***

No new information on biological parameters was available. The assessment model used the best survival estimate for humpback whales in West Greenland (Larsen and Hammond, 2004), and a uniform prior on the MSYR (1+) from 0.01 to 0.075, with the maximum value corresponding to an IWC agreed maximal growth rate of 0.106 (IWC 2007).

***Abundance***

The estimate of 3,272 [2](CV 0.50) humpback whales off West Greenland in 2007 is accepted by the SC, and a time series of uncorrected estimates from aerial surveys was presented to the assessment WG (Table 3). This time series showed an annual rate of increase of 9.4% $yr^{-1}$ (SE 0.01) between 1984 and 2007. It was noted that similar or even higher rates of increase have been observed for this species in other areas, including Iceland (Pike *et al.* 2005, 2009) and Antarctica (Matsuoka *et al.* MS 2004).

| Year | M | S |
|---|---|---|
| 1984 | | 138 (0.28) |
| 1988 | 357 (0.16) | 231 (0.11) |
| 1989 | 355 (0.12) | |
| 1991 | 376 (0.19) | |
| 1992 | 348 (0.12) | |
| 1993 | | 873 (0.53) |
| 2005 | | 1,158 (0.35) |
| 2007 | | 1,020 (0.35) |

**Table 3.** The time-series of uncorrected survey (S) and mark-recapture (M, from Larsen and Hammond 2000) abundance estimates for West Greenland humpback whales, with the CV given in parenthesis.

***Catch data***

Historical catch data were obtained from the IWC Secretariat with the assessment being based on a low and a high catch series. The low series included Greenlandic catches only (starting in 1750), and the second included also 10% of the catches in the West Indies (starting in 1664). This is twice the suggested maximum from a

[2] This estimate was subsequently changed from 3,299 after a small error was discovered.

comparison of abundance estimates from West Greenland and the West Indies in 1992/93.

***Assessments***

A Bayesian assessment, based on the above-mentioned abundance estimates and catch histories, attempted to determine both the current trend in abundance as well as the population dynamic processes that operate on the longer timescale. There was statistically decisive support for the rejection of a density-regulated model as an appropriate model of the long-term dynamics of humpback whales off West Greenland. The dynamics are better described as damped cyclic, although the density-regulated, as well as the exponential, model provide good fits when the model is initialized recently (last two decades). The assessment estimated an equilibrium population abundance between 1,700 (90% CI, 1,500 to 2,000) and 2,700 (90% CI, 2,300 to 3,100) whales, a 2008 depletion ratio between 0.88 (90% CI, 0.44 to 1.6) and 1.3 (90% CI, 0.71 to 2.4), a 2008 exponential growth rate of 0.09 (90% CI, 0.06 to 0.11), and a 2008 replacement yield between 160 (90% CI, 72 to 370) and 220 (90% CI, 96 to 510) whales per year.

The **SC notes** that the problem identified above of explaining the long-term dynamics of West Greenland humpback whales with a traditional density regulated model is consistent with earlier findings on the long-term dynamics of humpback whales throughout the North Atlantic (IWC, 2002, 2003).

***Management procedure***

The **SC finds** that the AWMP-C procedure (Witting 2008; IWC 2009) would be appropriate for providing management advice for West Greenland humpback whales. For a need of up to 20 humpback whales, this procedure sets the yearly strike limit for a five-year period equal to 2% of the lower 5$^{th}$ percentile of the most recent abundance estimate.

The procedure has been simulation tested for long-term (*i.e.* 100 years) performance on West Greenland humpback whales. This testing was based on trials that assume a yearly need of 10 to 20 whales, a MSYR of 2% and 4%, a MSYL from 0.5 to 0.8, a1970 depletion from 0.2 to 0.8, and a 2008 abundance of 600, 1,300 and 2,500 whales (IWC 2009). The biological parameters in the simulation trials were given by uniform priors from 0.9 to 0.99 for 1+ survival, from 0.5 to max(0.95, adult survival) for age class zero survival, from 4 to 7 years for the age-at-maturity, and from 2 to 3 years for the calving interval.

The conservation criterion was met by the procedure for all trials with a final population depletion well above 60% of the carrying capacity at the end of the simulation period.

***Management advice***

Using the fully corrected 2007 estimate of 3,270 (CV 0.50) humpback whales off West Greenland, the **SC concludes** that strikes of up to 20 humpback whales per year from 2010 to 2015 would be safe. This number is not to be compared directly with the lower 90% credibility estimate of the replacement yield (72-96 whales per year). The estimate of replacement yield is based not only on the current abundance but also on the estimated increase in abundance, while the AWMP-C procedure was constructed to ensure safe long-term catches for humpback whales given a need of up to 20 humpback whales per year. The **SC notes** that the assessment conclude that the probability that humpback whales off West Greenland will continue to increase is larger than 0.99, even with a total annual removal of 20 whales over a 5-year period.

***Recommendations for research***

Should management advice on West Greenland humpback whales turn out to be a reoccurring request, the **SC notes** the need to consider more detailed simulation testing of the AWMP-C procedure, including a change of the procedure to apply a time-series of abundance estimates rather than just the most recent estimate. Such testing should be carried out before the procedure is used for the third time to provide management advice for a 5-year period.

#### 9.2.2 Other updates

Nothing to report.

#### 9.2.3 Future work

Nothing to report.

### 9.3 Sei whale

**R.3.5.3:** A new Council request asked the SC to make a state of the art investigation about the possibility of providing a status assessment for sei whales in East and West Greenlandic waters and in waters west of Iceland. The request was dealt with by the Large Whale Assessment WG.

#### 9.3.1 WG reports

Abundance estimates are available from the NASS surveys in the Central North Atlantic (1989 and 1995) and one more could be produced from the 2007 surveys. In addition, estimates for East and West Greenland area are available from the 2005 survey.

These estimates are incomplete in temporal and spatial coverage and cannot be used for a formal assessment of the stock’s maximum sustainable yield. The estimates, however, could be used as minimum estimates. The **SC concludes** that assessments with minimum estimate of sustainable yield rates should be feasible once a minimum abundance estimate from the 2007 surveys has been produced.

#### 9.3.2 Other updates

There were no other updates.

#### 9.3.3 Future work

The **SC recommends** that:

- Sightings surveys, targeted at sei whales should be conducted in the Central North Atlantic during peak abundance of the species in these waters, *i.e.* late summer/fall.

- Satellite tagging of sei whales off Iceland and West Greenland should be conducted to complement the recent tracking off the Azores.

### 9.4 Minke whale

**R.3.3.4:** The Council had requested the Scientific Committee to conduct a full assessment, including long-term sustainability of catches, of common minke whales in the Central North Atlantic once results from the 2009 survey become available. The request was dealt with by the Large Whale Assessment WG.

The SC considered that implementation of the IWC RMP (IWC 1994a and b) to calculate catch limits provided an appropriate basis to address the Council's request. The RMP can be applied at a "*Small area*" level, or to combinations of such *Small areas*. For the Central North Atlantic minke whale population, four such areas are concerned: the Jan Mayen area (CM), the Icelandic coastal area (CIC) in which Icelandic catches would concentrate, the East Greenland area (CG) and the Icelandic pelagic area (CIP) – see Fig. 1 of the WG report.

#### 9.4.1 WG Reports (Abundance and Assessment)

***Abundance***

T-NASS estimates of minke whale abundance which have been endorsed for assessment purposes are shown in Table 2. Estimates for all areas except Norway have been provided to and reviewed. Several estimates require further work (Iceland-Faroe Islands-Extension) and/or documentation (Greenland shipboard) before they can be considered for endorsement (see Table 5 (Item 11) for details).

The different North Atlantic surveys from 2007 as well as the mosaic Norwegian surveys are considered additive, except for addition between the Icelandic shipboard and aerial surveys. The sum of all estimates provides a point estimate of minke whales in the North Atlantic in excess of 150,000 animals.

***Central North Atlantic***

***Stock structure and biological parameters***

In line with past views expressed by the SC and the SC the International Whaling Commission, the WG decided to assume a one-stock hypothesis for the Central North Atlantic area. The biological parameter values used reflect those adopted by the SC and the IWC SC in previous assessments for this stock.

***Abundance***

Two new abundance estimates were presented to the Large Whale Assessment WG. An aerial survey conducted in Icelandic coastal waters in 2009 produced a cue counting estimate of 5,900 mine whales (95% CI, 3,423 to 8,803). This estimate is not $h(0)$ corrected for bias due to visible cues being missed by observers (perception bias). The available evidence indicates that both primary observers did miss cues within 200 m of the plane, suggesting that correction for this bias would result in a higher abundance estimate. Although the 2009 estimate is biased downwards and should be corrected, it does confirm the decreased abundance in Icelandic coastal areas first detected in 2007.

The second new abundance estimate was from the 2007 shipboard sightings survey (T-NASS). As previous abundance estimates for minke whales from the Icelandic and Faroese NASS ship surveys, the new estimate is not corrected for perception bias (visible whales that are missed by observers) or for availability bias (whales that are missed because they are diving while the vessel passes). The abundance was estimated to 10,782 (95% CI, 4,733 to 19,262) for entire survey area covered by the dedicated vessels. This estimate should be considered negatively biased by uncorrected perception and availability biases, and possibly also by movement of whales in response to the vessels. Unfortunately, the double platform data collected are insufficient to correct for these biases. Furthermore, the survey vessels were unable to cover the area off East Greenland, an area that had high densities of minke whales in previous surveys, because of unfavourable weather and ice conditions. In addition, coverage was poor in the northern areas, and within this area minke whale densities were highest near the northern boundary of the surveyed area. This should therefore be considered a minimum estimate for the survey area, and probably more downward biased than some previous surveys.

Estimates of minke whales from Icelandic aerial and shipboard surveys of the central North Atlantic during 1987-2007 were reviewed. Comprehensive coverage took place in three years: 1987, 2001 and 2007, with abundance estimates totalling 37, 62 and 21 thousand whales respectively. The WG agreed that this drop from 2001 to 2007 is primarily a consequence of a much reduced estimate from aerial surveys of the Icelandic coastal region, representing only a small proportion of the distribution area of the Central North Atlantic stock. Possible reasons for this decrease include changes in spatial/temporal distributions as the most likely explanation. While a population decrease seems unlikely, it cannot be completely excluded. A decline, however, cannot have been caused by the low level of catches in the area (a total of 326 in the past 7 years).

Overall the fluctuations in numbers and density in the Icelandic/Faroese ship survey can largely be attributed to 1) changes in the size of the survey area as a whole, especially the size of the high-density northern area, and 2) lack of coverage in the area near East Greenland in some years. In the absence of any obvious indications of an increase in minke whale natural mortality around Iceland, it is unlikely that the trend in abundance reflects a real decline in population size. None of the surveys covered the entire distribution of the population and apparently, a substantial number of minke whales moved out of the survey area between 2001 and 2007. At present, the mechanism behind these re-allocations of minke whales is not fully understood. However, judging from recent changes the distribution of many marine species, which are reflected in the diet of minke whales around Iceland (SC/17/AS/06), it seems plausible that the large-scale ecological changes in the North Atlantic are driving the changes in distribution of minke whales.

***Assessments***

Assessments of the Central North Atlantic minke whale population have been presented in previous reports (NAMMCO 2000, 2005 and 2010c). They uniformly show a resource reduced only slightly below its pre-exploitation level, because cumulative past takes have been small relative to estimates from surveys of the recent abundance of the population. There was insufficient time to rerun these analyses for this meeting to take account of the most recent survey data. However, these further data are not such as would result in a qualitative change to the earlier results mentioned above.

***Management Advice***

For the CIC *Small area*, there are four aerial survey estimates (1987, 2001, 2007 and 2009) of abundance to consider for input to the RMP. All estimates have been formally approved except for the 2009 estimate, which needs to be examined for *h*(0) correction. Ideally, estimates should be comparable and corrected for known biases.

Two views emerged on the inclusion of the 2009 estimate in the RMP computations: 1) the *h*(0) correction was unlikely to be large, so that the 2009 estimate should be included; and 2) there were different features in the 2009 data compared to earlier years (e.g. considerably larger average radial distances to sightings), the implications of which for *h*(0) were unclear, so that the 2009 estimate should not be used until the adjustment for *h*(0) has been effected. The SC decided to explore both the option of including and excluding the 2009 estimate.

The SC considered that in the absence of any indication of stock structure for minke whales within the Central North Atlantic it would be more appropriate to treat the whole of the Central North Atlantic (CM+CIC+CIP+CG) as a *Small area* for the purposes of applying the RMP. However, this raises the difficulty that different parts of this region have been surveyed in different years. There is an approach which can adjust for this through the computation of additional variance to provide the requisite inputs for the RMP (IWC 1994), but there was insufficient time to complete the computations. The **SC recommended** that application of this approach be pursued in the near future to provide a basis for minke whale catch limit calculations for the Central North Atlantic as a whole.

The NAMMCO SC was informed that the IWC SC has recommended to their Commission, on the basis of simulation trials, that for single stocks, for which there was no stock structure uncertainty, TL for the RMP ranging from 60% to 72% were safe from a conservation perspective (SC/17/AS/O12). For minke whales in the Central North Atlantic there is no major uncertainty about stock structure, so that the single stock conclusion can be considered to apply. Table 4 shows the estimated total removal levels over the range of TL for the CIC and CM area. For the CIC area, removal levels are given with and without the 2009 abundance estimate, and with both of the 2007 abundance estimates that have been accepted by the NAMMCO SC.

The SC **concludes** that annual removals of up to 216 minke whales from the CIC area are safe and precautionary. The advice is conservative in the sense that it is 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 minke whales from the CM area is a safe and precautionary management advice.

| Abundance | Tuning level | CIC | |
|---|---|---|---|
| | | Excluding the 2009 estimate | Including the 2009 estimate |
| Lower 2007 abundance in CIC | 60% tuning | 248 | 216 |
| | 72% tuning | 156 | 135 |
| Higher 2007 abundance in CIC | 60% tuning | 277 | 235 |
| | 72% tuning | 175 | 148 |

**Table 4.** Estimated annual total removals from the CIC area for TL 60% and 72%.

The basis on which the RMP was tested indicates that these levels can apply for the next 5 years before a revision is needed. However, in case further data becomes available, including a revised abundance estimate for 2009 and RMP application to the combined CM+CIC+CIP+CG area, the management advice could be revised sooner. The **SC recommends** that **Council should decide** on the duration of the advice.

While there was agreement within the SC that the managements advice on minke, based on RMP TL 60% was safe, there were different views within the SC on whether or not to include in the report results based on higher TL (lower catch levels).

Some members reminded the SC that, as a general rule, management advice from the SC should aim at maximizing yield within the limits of sustainability and precautionary approach. They underlined that if the recommended catch levels based on TL of 60% are sustainable and precautionary, it goes without saying that any catch levels below this (as the ones yielded by employing TL 72%) are also sustainable. Their view is that for highly depleted stocks it is sometimes useful to present a range of sustainable catch options with stock projections into the future for the Council to decide on the preferred rate of rebuilding of the stock (e.g. narwhal and beluga), but for stocks close to or above MSYL, like fin and minke whales, this would not apply.

#### 9.4.3 Future work

The **SC recommends**:

- To calculate, as soon as possible, catch limits based on running the RMP on the Central North Atlantic medium area, with catch cascade allocation of catches to small areas.
- That the 2009 survey be corrected for *h*(0) as soon as possible and that the management advice be adjusted in accordance with this estimate.
- That the 2007 aerial survey abundance estimate be corrected for *h*(0) and error in distance measurements as far as possible e.g. using the methods applied to the 2001 survey (Borchers *et al.* 2009).
- That line transect density should be estimated for 2007 and 2008 and 2009 surveys, along the lines of Pike *et al.* (2009). For comparison, the methods used in SC/17/AS/09 should be applied to the Icelandic aerial survey data to calculate alternative corrected abundance estimates.

- That further studies on stock structure of North Atlantic minke whales should be conducted using genetic techniques and satellite tracking.
- That the relationship between the fluctuations in abundance estimates around Iceland and the simultaneous ecological and environmental changes be examined for possible explanations of the suggested large-scale re-allocations of minke whales between different parts of the North Atlantic.

### 9.5 Narwhal

**Age determination workshop**

Lockyer convened with a group of age determination experts in October 2009, in Quebec, in connection with the abundance WG meeting and the Biennial Conference of the Society of Marine Mammalogy. The group discussed the need for one versus two meetings, the timing and the location. While no decision was taken about holding one or two meetings, it was suggested that the meeting be organized early in 2011, not least to allow the presentation of ongoing work on aspartic acid racemisation. Aleta Hohn offered the use of her laboratory in Beaufort, South Carolina, as the venue for the practical work. Lockyer mentioned that the contributions to the workshop would ideally form a complete overview of the techniques for age determination in marine mammals and would be very useful if collected in one publication.

The **SC recommends** proceeding with the organisation of the workshop and that the working papers from the meeting be considered for collection in an “Age determination in marine mammals” volume of the NAMMCO Scientific Publication Series. Lockyer **should proceed** in contacting potential authors for expressions of interest and **should compile** a tentative chapter outline for approval at the next Council meeting in September 2010.

**Greenland**

A narwhal survey was conducted in the North Water polynya in May 2009 and it will be repeated in 2010 due to unusually large amounts of open water in 2009. The next winter/spring survey off West Greenland for narwhal and beluga is planned for 2012. A tagging programme for narwhals in East Greenland is scheduled for August 2010, and tagging in West Greenland continues in Qaanaq (June-July) and Uummannaq (November-December).

JCNB is scheduled to meet again in 2011. But new data is scarce, and with a new spring survey in 2012 it might be profitable to hold a scientific meeting in 2013. The **SC recommends** a JWG meeting with assessment updates no later than the winter 2013/14, maybe with a short meeting already during the winter 2010/11 or 2011/12. The final decision on the timing of the meeting/s should be determined by the parties (Greenland and Canada) before the Council meeting at the end of August.

The **SC is pleased** to see that the quotas for narwhal in Greenland are matching the advice on sustainable removals. It **reiterates** that all struck and lost animals are included in the advice, and **again strongly recommends** that struck and lost data be collected from all areas and types of hunt.

**9.6 Beluga**

For information on planned surveys, tagging and the next JWG meeting with JCNB, see the section on narwhal (item 9.5).

The **SC is pleased** to see that the quotas for beluga in Greenland are matching the advice. It **reiterates** that all struck and lost animals are included in the advice, and **again strongly recommends** that struck and lost data be collected from all areas and types of hunt. It also **reiterates the recommendations** that catches should be banned:

- south of 65°N
- in May to October between Sisimiut and Maniitsoq
- in June to October in Disko Bay
- in June to August between Uummannaq and Qaanaaq.

**9.7 Northern bottlenose whale**

**9.7.1 Update**

Last year the SC reiterated its recommendation that Faroese and Icelandic feeding data be worked up into a paper and urged its presentation as a document to the next SC meeting.

Preliminary feeding data were presented at this meeting on 36 whales stranded/landed/by-caught in the Faroe Islands and 6 whales stranded in Iceland (NAMMCO SC/17/17). The diet of the Icelandic whales was dominated by *Gonatus sp.*, in accordance with feeding in an ecosystem dominated by one oceanic cephalopd species: the Boreoaltantic armhook squid, *Gonatus fabricii*. The diet of the Faroese whales was much more varied. Although *Gonatus* was always present it only represented 50% of the biomass eaten and was accompanied by many over species, some known to have a much more southern distribution. This pointed to the possibility that the Faroese whales, although thought to be in their southward migration at that time of the year, could actually have been through warmer waters before passing through the Faroe Islands. Alternatively, the distribution of squid prey could be wider than known.

**9.7.2 Future work**

The **SC was pleased** to see that the analysis of the feeding data was ongoing and **recommends** that the analysis be completed and that the publication be presented to the next meeting.

The **SC recommends** that the analysis of the distribution and sighting rate data from the T-NASS Icelandic-Faroese area (26 sightings) be looked at in combination with CODA's data and compared with earlier surveys for possible trend information.

The **SC notes** that the recommendation to analyse acoustic data cannot be executed because it is not possible to identify bottlenose whales in the recordings.

**9.8 Killer whale**

**9.8.1 Update**

The effects of low frequency military sonars (1-7 kHz) on whales are being investigated in Norway, with target species being killer whales, pilot whales and sperm whales.

### 9.9 Pilot whale

#### 9.9.1 WG report (Abundance)

T-NASS estimates of pilot whale abundance which have been endorsed for assessment purposes are shown in Table 2. Acceptable estimates for the major areas (Iceland & Faroe Islands) are still missing (see Table 5 (Item 11) for recommendations on further analyses). The **SC urges** for the completion of the analysis because the best available estimate with the most extensive coverage is too old (1989) for management purposes.

An endorsed estimate from West Greenland was welcomed as the first estimate in this area where the species is harvested. The different surveys from 2007 as well as the mosaic Norwegian surveys are considered additive, when estimates become available.

#### 9.9.2 Other updates

***Faroe Islands***

The attempts to track animals will continue with the small adjustment of offshore fieldwork. Encounters of pilot whales during a planned harbour porpoise aerial survey in summer 2010 will be used to gather information on group size.

The SC was informed that the implementation of the intensive short term catch sampling programme of sex and age distribution over a three year period (for assessing within- and between-year variability) needed to the definition of a long term monitoring programme awaits the Ministry of Fisheries for funding and political goodwill.

The **SC reiterates** its previous recommendations that the latest satellite tagging data from 2004 be published as a priority. The **SC also reiterates** its recommendation on the timely implementation of the three-year catch sampling programme, so that a long term cost-effective monitoring programme can be timely defined and implemented. In addition it also **reiterates** its recommendation about the timely completion of the analysis of the T-NASS data for the Icelandic-Faroese area, including an index of relative abundance for areas common to all surveys. The **SC also reiterates** its recommendation that the comparative analysis of groups sizes and sightings rates be undertaken for the NASS-T-NASS series of surveys, as well as the investigation of the effect that a change in the group size estimation procedures has on the abundance estimates.

### 9.10 White-beaked, white-sided and bottlenose dolphins

#### 9.10.1 WG report (Abundance)

T-NASS estimates of dolphin abundance which have been endorsed for assessment purposes are shown in Table 2. Estimates are unfortunately still missing from several species in several areas, including the Icelandic coastal area, the Icelandic-Faroe Islands area and off Norway.

The estimate for white-beaked dolphins from West Greenland was welcomed, as the first abundance estimate in this area where the species is harvested.

#### 9.10.2 Other updates

Lockyer reported from the *Lagenorhynchus* genus workshop held in connection with the European Cetacean Society's annual meeting in Stralsund, Germany, April 2010 (SC/17/O-03). The workshop was attended by 34 persons, all of whom have been involved with *Lagenorhynchus* research. This report likely represents the most up-to-date collation of all information on the two species, and highlighted the areas of knowledge lacking. There was a proposal to make this a standing working group to meet regularly and exchange updated information.

The **SC notes** that the results from the programme on the biology of the white-sided dolphin in the Faroe Islands had not been submitted for presentation to this meeting. The Faroese report that the analyses are nearly completed and that final results will be submitted to the next SC meeting.

#### 9.10.3 Future work

The **SC notes** that the data on life history and abundance for any of the three species is still not sufficient for an assessment and **recommends** that Faroese samples for diet and life history parameters from 350 white-sided dolphins be finalised and at the same time that an abundance estimate from the 2007 survey be attempted.

### 9.11 Harbour porpoise

#### 9.11.1 WG report (Abundance)

T-NASS estimates of porpoise abundance which have been endorsed for assessment purposes are shown in Table 2. Although harbour porpoise was a target species for Iceland, an abundance estimate is still lacking for this area. The endorsed abundance estimate for West Greenland was welcomed as the first estimate in this area where the species is harvested.

#### 9.11.2 Other updates

***Greenland***

With the new abundance estimate for West Greenland, the availability of historical and present harvest levels, and an ongoing study on life history parameters, Greenland is preparing for an assessment of this species as requested by Council (R.3.10.1).

***Faroe Islands***

A dedicated harbour porpoise aerial survey is planned in the Faroe Islands in summer 2010.

As recommended by the SC, the survey will be kept compatible with the SCANS II and T-NASS aerial surveys. Some of the observers will also be the ones having flying the SCANS II and the Icelandic T-NASS aerial surveys.

***Future work***

The **SC recommends** that an assessment meeting for harbour porpoises in all areas be held during the winter 2011/12.

The **SC recommends** that the Faroese authorities make sure that obligatory reporting of takes of harbour porpoises is effective.

Total removal estimates should be obtained for all areas before the planned WG meeting. It also **recommends** that abundance estimates from the 2007 survey in Iceland and the 2010 survey in the Faroe Islands become available before the meeting.

### 9.12. Bowhead whale

#### 9.12.1 Update

For West Greenland there is an annual quota of two bowhead whales for the period 2008-2012. No whales were caught in 2008, and this quota was transferred to 2009. Three whales were caught in 2009 and the remaining whale was transferred to 2010. A catch of 3 bowhead whales is planned for 2010. At the time of this meeting, two animals had been taken. Thanks to good collaboration with the hunters, biological samples have been secured from all the bowhead whales taken so far.

A walrus survey in the Northeast Water polynya in 2009 encountered 13 sightings of bowhead whales.

#### 9.12.2 Future work

The spring aggregation of this species in the Disco Bay area in West Greenland will be covered by a planned 2012 survey for beluga and narwhal.

### 9.13 Other species

#### Sperm whales

No abundance estimates are yet available from T-NASS. The **SC recommends** that estimates be obtained for both the acoustic and the visual data of the Icelandic and Faroese area.

CODA found good agreement between an estimate obtained from acoustic data and an estimate obtained from visual data. This indicates that the availability bias may be similar for the two survey methods for this species. Additional comparisons of visual and acoustic estimates for this species were **recommended**.

Ólafsdóttir informed that the Icelandic acoustic data are being analysed and prepared for estimation of abundance. For more details see under point 11.1 **Acoustic training course**.

## 10. GENERAL MODELS FOR MANAGEMENT

The **SC noted** the usefulness of basing its advice on the large amount of simulation testing and other work conducted within the IWC SC using the Revised Management Procedure approach. However, it also noted that this might not be possible or appropriate for all stocks. In addition, reliance on the IWC work may limit the possible questions that can be raised by NAMMCO SC. The **SC recommends** that the Large Whale Assessment WG investigate how NAMMCO can take over a larger and more direct role in this work in the future so that it can be less dependent on other organizations.

The **SC also recommends** that the Large Whale Assessment WG at its next meeting should investigate the trade-off space between catches and conservation over a range of tuning levels for management procedures that have already been thoroughly investigated but not examined in detail by NAMMCO.

## 11. SURVEYS

### 11.1 T-NASS

Table 5 summarises the analyses and improvements that remain to be done for the different species. The deliberations about abundance estimates of the WG's on Abundance Estimates and Assessment were in general accepted by the SC.

Besides these the SC **reiterates** the importance of producing a common 2007 document that describes the general distribution of cetaceans throughout the entire T-NASS survey area, including the extension areas, as well as CODA and SNESSA.

The SC **recommends** that Greenland analyse and publish estimates from the shipboard survey in 2007 to allow when possible density comparisons to the later 2007 estimates obtained from the aerial surveys in September. The SC **notes** that this may not be the case because of the different techniques and coverage of the two surveys.

The SC **recommends** that integrated model-based analyses of CODA and T-NASS data be undertaken as soon as possible. The Group considers that most new information would be gained from combined estimates for pilot, minke, fin and sperm whales as well as white-beaked dolphins.

The SC urged the Secretariat to proceed with the transformation of the T-NASS data to a format similar to the one employed by the IWC and archived them at the NAMMCO Secretariat with the necessary clauses for use restrictions. All T-NASS data holders were urged to cooperate with the Secretariat in providing the data in a timely manner.

The SC **reiterates** the recommendation that a T-NASS publication be developed in a single issue of *J. Cetacean Res. Manage.* in cooperation with the IWC, with the general paper on distribution as a trailer.

| **Species** | **Survey area and type** | **Analyses** |
|---|---|---|
| All species | Norway | No abundances have been provided to the AE WG from Norway. |
| All species | Iceland | Elucidating whether there is a problem in using the last distance estimation for each sighting instead of the first, which is standard practice for line transect surveys of cetaceans. |
| Fin whale | Greenland aerial | 1. Post-stratification of blocks 4 (which includes much of the estimate) and 7 to only include areas actually surveyed (MRDS&CDS estimates);<br>2. Examination of the effect of the level of pooling of expected group size on stratum and total estimates (MRDS&CDS estimates);<br>3. Examination of the effect of right truncation on the MRDS estimate, particularly truncation to the same degree as the CDS estimate. An alternative would be to truncate the CDS model equivalently to the MRDS model.<br>4. Detailed trend analysis |
| Minke whale | Canada aerial –GSS | Investigate possibility of the possibility of correcting for availability bias using the methods employed in Greenland (SC/17/AE/08). |
| | Greenland shipboard | Provide documentation for the estimate |
| Humpback whale | Iceland-Faroese shipboard | Investigate for the possible presence of responsive movement. If such evidence is found then a MRDS model assuming full independence should be used. |
| | Iceland-Faroese shipboard and Iceland costal | Combine Iceland-Faroese shipboard and Iceland coastal surveys by employing abundance estimates from the shipboard surveys in the overlapping areas and to use the post-stratified aerial survey for the rest. |
| | Greenland shipboard | To be done |

**Table 5 – contd next page.** Summary of the analyses/improvement to analyses remaining to be done from the T-NASS survey for the different species.

| | | |
|---|---|---|
| Pilot whale | Iceland-Faroe Islands | 1. Provide a CDS estimate<br>2. Complete the present analysis looking in particular at: - ”edge effects” showed by the MRDS model - check the actual distribution of sightings used (Fig.5 and 6 in document SC/17/AE/13 are different)<br>3. Provide un index of relative abundance for areas common to all surveys |
| | Greenland aerial | Reconsider correction for availability |
| Harbour porpoise | Iceland aerial | Analysis remains to be done |
| Sperm whale | Iceland-Faroe Islands | The analysis should be prepared, both for the acoustic and the visual data |
| Bottlenose whale | Iceland-Faroese | Analysis of shipboard sightings data remains to be done |
| Dolphins | Iceland-Faroese shipboard and Iceland costal | Analysis remains to be done |

**Table 5 contd.** Summary of the analyses/improvement to analyses remaining to be done from the T-NASS survey for the different species.

**Acoustics training course**
A 5-days training course in acoustic data analyses was held at the Marine Research Institute in Iceland 23-27 November 2009. The course was tutored by René Swift from the Sea Mammal Research Unit, Scottish Oceans Institute, University of St. Andrews. The purpose of the course was to train individuals for analysing T-NASS acoustic data. Topics covered during the course were: (1) Introduction to PamGuard software for real time data collection and post processing or the raw wav file data. (2) Introduction to IFAWs RainbowClick software for real time data collection and offline analysis of click files. (3) Post processing of click trains with Matlab to estimate animal locations and perpendicular distances. (4) Export of data for abundance estimation with Distance. (5) Hardware configuration for future surveys.

Four attendees from the course are currently analysing acoustic files from three Icelandic T-NASS vessels (approx. 76 survey days). The analyses focus on identifying sperm whale events and estimate the perpendicular distances to survey track lines. Other observed clicks are marked for potential later studies. The analyses will provide data on acoustic survey effort and sperm whale sighting data applicable for estimates of absolute abundance. The completion of these analyses is expected by November 2010.

The **SC recommends** that these data be used for producing an abundance estimate in a timely fashion. It noted that the Faroese data are not included in these analyses. The **SC**

**recommends** that they are also analysed in the same way as the Icelandic data and that an abundance estimate is provided.

### 11.2 Future surveys

The most opportune time for the next large-scale survey would be in the period 2013 to 2015 and planning should begin as soon as possible. The **SC establishes** a WG on the planning of future surveys to provide directions, initiate planning and negotiations with survey partners as soon as feasible. This is best done by bringing in participation from all potential partners.

The **SC agrees** that coordination at or beyond the level of the T-NASS was desirable and should be pursued for the next round of surveys. Many possible improvements and suggestions, both regarding the planning process and more practical considerations have been identified (NAMMCO SC/15/09 and SC/17/20) and should be taken into considerations, starting by initiating the planning in good time. Observer training and experience has been considered an important issue in all areas and pre-cruise training considered as an absolute necessity. The necessity for improving species identification and distance estimates had also been underlined as well as the necessity of using equipment adequately robust and tested. Again this pointed to the necessity to start the planning and practical preparation early enough, so all the improvement proposed could be addressed.

The WG should be aware that one round of the Norwegian multiyear survey is running out in 2013, making 2014 perhaps a better option for the coordinated surveys because this would allow Norway more freedom for choosing an area contiguous to the rest of the survey and therefore coordinate more closely with the rest of the group.

## 12. NAMMCO SCIENTIFIC PUBLICATIONS

Acquarone presented the chapter list for volume 8 in the NSP series – Harbour seals in the North Atlantic (SC/17/10). The Delegates were informed that the final procedures for lay-out and publication had been initiated and the volume was planned to be published before the summer.

Acquarone continued with the presentation of the suggested contribution list to a volume on walrus (SC/17/13) and reminded the Delegates that the volume had already been approved in principle by Council (NAMMCO 2010a).

Winsnes **informed** the SC that the National Library of Norway had been approached for the production of electronic versions of the past NSP volumes in view of an on-line publication of the whole series.

The discussion subsequently verged on publication speed and Acquarone presented the notes on this matter that he had produced for the meeting (SC/17/10).

The **SC agrees** that for the future the NSP should be designed for on-line publication and that the contributions should be published on-line as soon as the review process is finished on a first-in first-out base bearing in mind that the NSP is not a journal. The **SC also requests** that the Secretariat reviews and updates the instructions to authors and editors accordingly.

## 13. DATABASES ON ABUNDANCE AND CATCHES

### 13.1 Abundance database

The **SC agrees** to maintain the email group on establishing an abundance database at NAMMCO. The **SC agrees** that the database should hold all endorsed estimates, that the email group should agree on a database format and report back to the Secretariat as soon as possible and inform the SC at its next meeting. The email group include Acquarone (Chair), Heide-Jørgensen, Øien, Gunnlaugsson, Mikkelsen and Witting.

The **SC agrees** to postpone discussions on whether the Secretariat should hold a database also on survey data.

### 13.2 Catch database

According to instructions from Council (NAMMCO 2010a, p.13), the **SC agrees** that NAMMCO should not attempt to hold a complete, detailed database of historical catches that could be used for generating catch series for assessment work. These data can instead be obtained from databases in the different countries, or from the IWC. NAMMCO should instead hold relatively simple catch series that provide insights in the number of individuals of different species harvested in different areas.

The **SC agrees** to maintain the email group on establishing a catch database at NAMMCO. The email group should agree on a simple format for submitting yearly catches to NAMMCO starting with an initial submission of catch histories. The group shall report back to the Secretariat as soon as possible and inform the SC at its next meeting. The email group include Acquarone (Chair), Ugarte, Ólafsdóttir, Haug and Mikkelsen.

## 14. WORK PROCEDURE IN THE SC

Regarding reporting from WG meetings the **SC agrees** that in the future:

- When WG chairs are not part of the SC, a convenor will be designated to convey information to the SC.
- A Summary for each WG report will have to be produced in conjunction with and attached to each WG report.

The SC document on “Responsibilities associated with WG meetings” was updated to include these changes (Appendix 3).

The **SC notes** that the amendments to the Rules of Procedure regarding its Membership had not been approved by Council at its meeting in 2009 due to time restrictions in the presentation of the suggested amendments. The **SC requests** the Secretariat to timely forward the amendments suggested at its 2009 meeting to Council.

The **SC agrees** that in the future the documents presented to its meeting should be divided into 3 categories:

1. Meeting documents
2. Supporting documents and
3. “For information only” papers.

**SC reiterates** its request for a timely reminder from the Secretariat to each country that a NPR is due and has to be circulated one month before the SC meeting.

## 15. FUTURE WORK PLANS

### 15.1 Review of Active Request

The **SC reviewed** the summary of requests (SC/17/11), updated the status of the requests, and considered the requests in relation to future WG meetings (Agenda item 15.3).

### 15.2 Scientific Committee

The **SC agrees** that its next meeting should be held in the Faroe Islands. Tentative dates were set to 4-8 April 2011.

It was a general view that the video-conference as a venue for the SC meeting this year worked surprisingly well this year. The method is, however, dependent on high quality equipment and it should probably not include more than four video groups. Also, the video-conference is limiting the possibilities to be assisted by observers and to have off-meeting discussions. A discussion of the possibility of having regular video-conference SC meetings instead of some of the face-to-face meetings will be taken up next year.

### 15.3 Working groups

The **SC recommends** that the following Working Groups meet before its next meeting, noting that other meetings may be held depending on new requests received from the Council:

***Coastal Seal Working Group***

Noting the closed and pending requests R.2.4.2 and R.2.5.2 from 2002 and 2007, the **SC recommends** that a WG on coastal seals be held to review the Norwegian management plan for grey and harbour seals, to perform assessments for grey and harbour seals in all areas, and to develop a common management model for both species in all areas. A meeting is planned for early 2011, and another meeting is likely required to fulfil the task. (Convenor: Tore Haug; Chair: Kjell Tormod Nilssen.)

***Working Group for Planning Future Surveys***

Noting that 2013 may be the best option for the next coordinated surveys, the **SC recommends** that a WG on the planning of future surveys be held between December 2010 and January 2011. Terms of reference should be to coordinate the year of the surveys, the time of year, and methods. (Chair: Geneviève Desportes.)

***WG on Large Whale Assessment***
Noting the recommended future work on the assessment and advice for Central North Atlantic fin and minke whales, the **SC recommends** an extra meeting on large whale assessment to be held between January and March 2011. (Convenor: Gísli Víkingsson; Chair: Lars Walløe.)

***WG on Abundance Estimates***
The **SC recommended** that an extra meeting on abundance estimates be held late 2010 or early 2011 to finalize not yet accepted estimates. This meeting could be combined with the meeting of the WG on Planning Future Surveys or held as a teleconference meeting if appropriate. (Convenor: Geneviève Desportes; Chair: Daniel Pike.)

**Working Group meetings planned after the next SC meeting**

***Harbour Porpoise Working Group***
Noting the open request R.3.10.1 the **SC recommends** that assessments of harbour porpoise be carried out for all areas if possible. The WG is planned to meet between fall 2011 and spring 2012. (Chair: Droplaug Ólafsdóttir.)

***Narwhal and Beluga Joint Working Group***
The **SC recommends** that a new JWG meeting be held to update assessments and advice for beluga and narwhal. The final timing of this meeting is left for the two parties –Greenland and Canada **-** to decide. (Convenor: Mads Peter Heide-Jørgensen; Chair: Rod Hobbs.)

### 15.4 Other matters
No other matters were raised at the meeting.

## 16. BUDGET

### 16.1 Spending in 2010
Last year the SC requested the Council to prioritize among its large number of active requests to the SC. The SC noted the response of the Council where the most important requests were listed with attached budget.

Acquarone presented the spending for 2010 which detailed the costs of the activities of the SC in relation to the approved budget. All costs were well within budget and funds were amply sufficient for the activities planned for the rest of the year. The SC decided to allocate some of the funds remaining on the undetermined activity “buffer” for 2010 to cover the costs of inviting one additional expert to the ICES-NAMMCO workshop on Observation Schemes for By-catch of Mammal and Bird (see item 7.1).

### 16.2 Budget for 2011
A draft budget was presented and approved bearing in mind that the list of activities for the SC for the coming year will depend on instructions and funds allocated from the Council.

## 17. ANY OTHER BUSINESS

Desportes presented document SC/17/18 on a Stock Status List for NAMMCO as encouraged by the Council (NAMMCO 2010a) and taking the fin whale as a model.

The **SC commends** Desportes' work and **recommends** her to continue with this effort.

## 18. MEETING CLOSURE

### 18.1 Acceptance of report

The report was accepted in a preliminary form at the end of the meeting Friday, 23 April 2010. The report was adopted by correspondence on 28 May 2010 at 16:00 hr.

### 18.2 Closing remarks

Chair Witting thanked all the convened Delegates in Greenland, Norway and the Faroe Islands as well as the technical staff who helped with setting up and running the videoconferencing equipment. He also thanked Zabavnikov and Walløe for their brief participation. He was joined by all the delegates in a special thanks to Dorete Bloch, outgoing member for the Faroe Islands, for having participated to the workings of the SC since its establishment and brought her very specific touch to the group.

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Appendix 1

## AGENDA

1. CHAIRMAN'S WELCOME AND OPENING REMARKS
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3. APPOINTMENT OF RAPPORTEUR
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        - 8.3.2 Future work
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9. CETACEANS STOCKS - STATUS AND ADVICE TO THE COUNCIL
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9.1.2 Other updates
9.1.3 Future work
9.2 Humpback whale
9.2.1 WG reports (Abundance & assessment)
9.2.2 Other updates
9.2.3 Future work
9.3 Sei whale
9.3.1 WG report (Assessment)
9.3.2 Other updates
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11. SURVEYS
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14. WORK PROCEDURE IN THE SC
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16. BUDGET
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Appendix 2

## LIST OF DOCUMENTS

| Document no | Agenda item | Title |
|---|---|---|
| SC/17/01 | | List of participants |
| SC/17/02 | 2 | Provisional Annotated Agenda (Draft) |
| SC/17/03 | 4 | List of Documents (Draft) |
| SC/17/NPR-F | 4.1 | National Progress Report –Faroe Islands |
| SC/17/NPR-G | 4.1 | National Progress Report –Greenland |
| SC/17/NPR-I | 4.1 | National Progress Report –Iceland (Draft version) |
| SC/17/NPR-N | 4.1 | National Progress Report –Norway |
| SC/17/NPR-C | 4.1 | National Progress Report –Canada |
| SC/17/NPR-R | 4.1 | National Progress Report –Russian Federation |
| SC/17/NPR-J/1 | 4.1 | National Progress Report–Japan / Large cetaceans 4/2008-3/2009 |
| SC/17/NPR-J/2 | 4.1 | National Progress Report–Japan / Small Cetaceans 4/2008-3/2009 |
| SC/17/04 | 5.1 | Observers Report: 61th Meeting of the IWC Scientific Committee, Madeira, May 2009 |
| SC/17/05 | 8.7 | Report of the NAMMCO SC WG on walrus, November 2009 |
| SC/17/05SC | 8.7 | Report of the NAMMCO SC WG on walrus. Copenhagen, 23-26 November 2009 |
| SC/17/06 | 5.3 | Report from the 2009 activities in ICES |
| SC/17/07 | 6.1 | Report of the NAMMCO SC WG on Marine Mammal and Fisheries Interaction, Copenhagen, March 2010 |
| SC/17/08 | 9.1, 9.2, 9.3, 9.4, 10.1 | Report of the NAMMCO SC WG on Large Whale Assessment, Copenhagen, March 2010 |
| SC/17/09 | All, 15.1 | Summary of requests by NAMMCO Council to the SC and responses |
| SC/17/10 | 12 | Status of NAMMCO Scientific Publications –Harbour Seal volume |
| SC/17/12 | 16 | SC Budget, incl. accounting for 2009 and draft budget for 2010 and 2011 |
| SC/17/13 | 12 | Proposal for NSP9 - Walrus |

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|---|---|---|
| SC/17/14 | 13 | Template for abundance estimates as input to the assessments |
| SC/17/15 | 9.1, 9.2, 9.4, 9.9, 9.10, 9.11, 11 | NAMMCO training course on cetacean acoustic data collection and analyses |
| SC/17/16 | 7.1 | Report on monitoring of marine mammal by-catch in Icelandic fisheries - statistics for 2009 and review of previous information |
| SC/17/17 | 9.7.1 | Desportes, G., Bloch, D., Víkingsson, G., Halldórsdóttir, G., Jacobsen T and Mikkelsen, B. Preliminary results on the diet of Northern bottlenose whale off the Faroe Islands and Iceland. |
| SC/17/18 | 12 | Template for a NAMMCO species status list – the fin whale |
| SC/17/19 | 6.1 | Network on Marine Ecosystem modelling to improve Ecosystem based management" MarEcoModelling |
| SC/17/20 | 9.1, 9.2, 9.4, 9.9, 9.10, 9.11 | Report of the NAMMCO scientific committee working group on abundance estimates meeting Quebec 7-9 October 2009. |
| SC/17/20s | 9.1, 9.2, 9.4, 9.9, 9.10, 9.11 | Summary of the SC WG group on abundance estimates |
| SC/17/21 | 15, All | Priorities and Work plan of the Scientific Committee in 2009-2010 |
| NAMMCO/18/05 | All | Report of the Sixteenth Meeting of the Scientific Committee |

**FOR INFORMATION DOCUMENTS:**

| | |
|---|---|
| SC/17/O-01 | Andersen *et al.* "Movement Patterns of Hooded Seals (Cystophora cristata) in the Northwest Atlantic Ocean during the Post-Moult and Pre-Breed Seasons". 2009. |
| SC/17/O-02 | Chassot *et al.* "Role of predation by harp seals Pagophilus groenlandicus in the collapse and non-recovery of northern Gulf of St. Lawrence cod Gadus morhua". 2009. |
| SC/17/O-03 | Report of the First ECS Workshop on White-Beaked & Atlantic White-Sided Dolphins, Stralsund, 21 March 2010. |
| SC/17/O-04 | Folkow *et al.* "Remarkable development of diving performance and migrations of hooded seals (Cystophora cristata) during their first year of life". 2009. |
| SC/17/O-05 | Hammill and Stenson "Comment on "Towards a precautionary approach to managing Canada's commercial harp seal hunt" by Leaper *et al.*". 2010. |
| SC/17/O-06 | Øigård *et al.* "Estimation of Pup Production of Hooded and Harp Seals in the Greenland Sea in 2007: Reducing Uncertainty Using |

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|---|---|
| | Generalized Additive Models". 2010. |
| SC/17/O-07 | Leaper *et al*. "Towards a precautionary approach to managing Canada's commercial harp seal hunt". 2010. |
| SC/17/O-08 | Salberg *et al*. "Estimation of seal pup production from aerial surveys using generalized additive models". 2009. |
| SC/17/O-09 | Sjare and Stenson "Changes in the reproductive parameters of female harp seals (Pagophilus groenlandicus) in the Northwest Atlantic". 2009. |
| SC/17/O-10 | Stenson *et al*. "Estimating pup production of Northwest Atlantic Harp Seals, Pagophilus groenlandicus: Results of the 2008 surveys". 2009. |
| SC/17/O-11 | ICES. "Report of the Working Group on Harp and Hooded Seals (WGHARP)". 2009. |
| SC/17/O-12 | Report of the study group for by-catch of protected species (SGBYC) 19-22 January 2009 ICES, Copenhagen, Denmark |
| SC/17/O-13 | Report of the Scientific Committee of the IWC 2009 - Madeira |
| SC/17/O-14 | Hammill and Stenson. "Abundance of Northwest Atlantic harp seals (1952-2010)". 2010. |
| SC/17/O-15 | Stenson "Total Removals of Northwest Atlantic Harp Seals (Pagophilus groenlandicus) 1952-2009". 2010. |
| SC/17/O-16 | Draft Annotated Agenda By-catch workshop |

ANNEX 1

**REPORT OF THE**
**NAMMCO SCIENTIFIC COMMITTEE WORKING GROUP ON ABUNDANCE ESTIMATES**

Department of Fisheries and Oceans, Quebec City, 7 - 9 October 2009

## 1. CHAIRMAN WELCOME AND OPENING REMARKS

Chairman Daniel Pike welcomed the participants (Section 5.7). He pointed out that the purpose of this meeting was to evaluate the abundance estimates of the different components of the T-NASS 2007 and associated surveys, to discuss and plan for further data analyses and to produce, where possible, combined abundance estimates for the entire area covered by T-NASS and associated surveys.

## 2. ADOPTION OF AGENDA

The adopted agenda is given in Appendix 1.

## 3. APPOINTMENT OF RAPPORTEURS

Acquarone was appointed as rapporteur with the help of the participants where needed.

## 4. REVIEW OF AVAILABLE DOCUMENTS AND REPORTS

Documents that were made available for the meeting are listed in Appendix 2.

## 5. T-NASS DATASET: validation, storage, formats, and availability

In 2008 the NAMMCO Scientific Committee recommended that T-NASS data be transformed to a format similar to the one employed by the IWC and be archived at the NAMMCO Secretariat with the necessary clauses for use restrictions (NAMMCO 2009). Acquarone reported that the Secretariat was prepared to receive the data and had funding to develop a data archive suitable to this need. The WG therefore urged the Secretariat to proceed with this and asked all T-NASS data holders to cooperate with the Secretariat in providing the data in a timely manner.

## 6. REVIEW OF ABUNDANCE ESTIMATES AND TRENDS

### 6.1 Fin whale

#### 6.1.1 T-NASS aerial Canada

Lawson presented documents SC/16/AE/12 and SC/16/AE/14. The former included information on the methodology employed during the Canadian megafauna aerial surveys and preliminary abundance calculation results. The latter more specifically addressed the question of bias correction for the Newfoundland and Labrador area components.

For the Canadian portion of the T-NASS survey, there were 144 sightings of fin whales, which were incorporated into multivariate, stratified line transect analyses used to estimate abundance in the programme Distance. Model detection functions were chosen to minimize Akaike Information Criterion values using all sighting data, and then post-stratified (see Lawson and Gosselin 2009 for methods). Too few sightings were made in the Labrador stratum (one fin whale) to obtain reliable abundance estimates. Corrections for availability bias have not been completed.

Using the MCDS approach the uncorrected abundance estimate for fin whales in the Newfoundland and Labrador (NL) portion was 677 fin whales (CV = 0.254; 95% CI 413 - 1,112), while in the Gulf and Scotian Shelf (GSS) portion there were an estimated 462 fin whales (CV = 0.28; 95% CI 270 - 791). Compared with a 1981 aerial survey of a smaller area and uncorrected for bias sources (478 fin whales; Hay 1982), there appears to be a positive trend in fin whale abundance in Newfoundland waters (although see discussion below of a possible delayed northward migration of fin whales during the 2007 survey period).

The estimates for the NL strata were corrected for perception bias using a mark-recapture analysis based on replicate sightings data from two observers (10 replicates from 35 unique sightings) on the right side of the survey aircraft. Using the MRDS approach with point independence, the perception-corrected abundance estimate for fin whales in the NL portion of the T-NASS was 1,254 whales (95% CI 765 - 2,059; $g(0)=0.54$ for the primary platform).

Gosselin informed the WG that too few sightings of fin whales were made in the tandem plane experiments to provide bias corrections for the GSS portion of the survey. It was also noted that responsive movement might be an issue for this platform (aircraft type and altitude) for some species, incl. fin whales.

At present the best (least biased) total estimate of fin whales in Canadian waters combines the partially corrected estimate from NL with the uncorrected estimate from GSS, for a total of 1,716 (CV = 0.40; 95% CI 1,035 - 2,850).

Comparison with earlier surveys suggests that fin whale numbers were lower in 2007 than previously. However, Lawson noted that there may have been a delayed migration into Canadian waters in 2007, according to reports from fishermen and whale watchers, and from initial results from the SNESSA survey, where sightings of fin whales in the area immediately south of the Canadian survey area were more numerous than in previous surveys.

#### 6.1.2 T-NASS shipboard Iceland/Faroe Islands

Paper SC/17/AE/O07 presented revised estimates from this component of T-NASS, which were first presented to the WG last year (NAMMCO 2009), than revised following the Group recommendation and later presented to the IWC Scientific Committee. The 2008 NAMMCO WG required further work on two issues before the estimate could be accepted.

The first issue involved correction of a suspected bias in radial distance estimation by the primary platform. Comparison of 30 distance estimates to duplicate sightings on one vessel revealed that, on average, perpendicular distances to sightings from the primary platform were 74.6% of distances to the same sightings from the tracker platform. Responsive movement, in this case attraction, was considered an unlikely explanation as comparison of primary and tracker sightings that were very close together in time showed the same pattern. Therefore a negative bias in distance estimation by the primary platform is suspected. If real, such a bias would result in the overestimation of abundance. However, the bias would apply only to non-duplicate sightings by the primary platform, as distance estimates by the tracker platform were used when available.

The discussion on this issue centred on the use of data from the trackers and the development of correction factors. It was noted that by having the trackers confirm the primary sightings one would obtain an independent distance estimation and better species determination: this should be implemented for future surveys. Since there was no precedent for such a correction in past surveys (and no way to derive one for surveys conducted before 2001, which used a single platform), the uncorrected estimate was considered acceptable for use in assessment. The Group underlined however that better estimates of distance by the primary platform were required and that this problem must be addressed in future surveys.

The second issue pertained to the use of the last distance estimation of for each sighting instead of the first, which is not standard practice for line transect surveys of cetaceans, although it has been used consistently in analyses of the Iceland/Faroese data. Gunnlaugsson indicated that this approach eliminates a possible positive bias due to random movement of the animals detected far ahead on the track line, but may introduce other biases if later surfacings are missed or due to responsive movement. The Group agreed that a reference was required to support this statement. The issue was not fully resolved, and Hammond and Gunnlaugsson volunteered to search the literature about this specific issue. It was however considered likely that any bias resulting from this practice would be very small.

The authors also noted that some post-stratification of particularly the NW block will be required to account for ice conditions, and agreed to provide revised estimates when this was completed. (This was completed after the meeting and the resultant estimates are noted below).

In conclusion the Group noted that the estimate uncorrected for $g(0)\neq1$ of 21,628 (95% CI 15,731 - 27,739) should be accepted for consistency with previous surveys while the issue of bias in distance estimation should be addressed for future surveys. When the surface areas of the western strata are corrected for ice cover, the resultant estimate decreases by 4.7% to 20,613 (95% CI 14,819 - 25,466). The $g(0)$-corrected estimate of 27,493 (95% CI 18,289 - 41,328) is likely closer to actual abundance and could be preferred for some purposes. Corrected for ice cover this estimate is reduced slightly to 26,117 (95% CI 17,401 - 39,199). These estimates are similar to those for 2001 for a similar area, so the increase observed over the period 1987-2001 (Víkingsson *et al.* 2009) has apparently ceased.

**6.1.3 T-NASS aerial Greenland**

Hansen presented document SC/16/AE/07, The effort was conducted off West Greenland in August-September 2007 from a Twin Otter. A total of 9,433 km of survey effort covered 21 strata (11 offshore, 10 fiords) in sea states <5 with a total stratum area of 220,924 $km^2$. The survey was conducted as a double platform survey and mark-recapture distance sampling (MRDS) techniques were used to correct for perception bias.

24 sightings of fin whale groups were collected. Based on conventional distance sampling techniques an abundance of 4,359 whales (CV = 0,45; 95% CI 1,879 - 10,114) was estimated. MRDS methods gave an abundance estimate of 4,468 whales (CV = 0,68; 95% CI 1,343 - 14,871). Both estimates are negatively biased because no corrections were applied for whales that were submerged during the passage of the survey plane. There is an apparent positive trend in abundance since 1989.

The Group found it unusual that the proportion of duplicate sightings increased with perpendicular distance. No clear reason could be given for this, but it was suggested that some cues might be easier to spot at a larger distance. This could also be an artefact due to the relatively small sample size, with only 8 duplicates.

The CDS estimate was nearly the same as the MRDS estimate, and more precise. This is contrary to expectations as the MRDS estimate is corrected for perception bias and should therefore be higher. No clear explanation for this was provided, but it was noted that the two analyses differed in their truncation of perpendicular distances and their level of pooling of mean group size. This latter difference apparently had a very large effect on estimated abundance in some strata. Also blocks 4 and 7 were poorly covered and should be re-stratified. The WG also noted the apparent increase in numbers since 1989, but suggested that this should be examined in more detail, taking account of differences in survey methods and their inherent biases.

There was also discussion about the use of specialised harbour porpoise observers in large whale surveys, an issue that also arose in consideration of the Icelandic aerial survey. Unfortunately no conclusion was reached, but the point was considered very important.

The WG concluded that the CDS estimate was acceptable for assessment purposes, but that further work was required before the MRDS estimate could be accepted. The following work was recommended 1) post-stratification of blocks 4 (which includes much of the estimate) and 7 to only include areas actually surveyed (both estimates); 2) examination of the effect of the level of pooling of expected group size on stratum and total estimates (both estimates); 3) examination of the effect of right truncation on the MRDS estimate, particularly truncation to the same degree as the CDS estimate. An alternative would be to truncate the CDS model equivalently to the MRDS model. It was also recommended that the apparent positive trend in abundance since 1988 be examined in more detail, taking account of differences in survey design, as well as field and analytical methodologies.

**6.1.4 CODA**

The abundance of fin whales (*Balaenoptera physalus)* and other baleen whales was estimated from data collected during shipboard sightings surveys as part of the Cetacean Offshore Distribution and Abundance in the European Atlantic (CODA) project (document SC/17/AE/O01). The survey area covered offshore waters beyond the continental shelf of the UK, Ireland, France and Spain. The area was stratified into four blocks and was surveyed by five ships during July 2007. Double platform methods employing the trial configuration (BT) method were used to estimate the abundance of fin whales and "large baleen whales" (fin, sei, fin/sei and blue whales) using the MRDS design-based method and also using density surface modelling. Primary perpendicular distances for duplicates were smaller than those from the Tracker platform, implying attractive movement, so a full independence model was used in analysis. Estimates from the two methods were comparable but model-based methods improved the precision and were considered best estimates. The density of large baleen whale species was greatest in the southern end of the survey area and water depth, temperature and distance to the 2,000m contour were important predictors of their distribution. The total abundance estimated for the entire survey area was 9,019 (CV = 0.11: 95% CI 7,265 - 11,200) fin whales and 9,619 (CV = 0.11; 5% CI 7,760 - 11,920) large baleen whales. The uncertainty around these estimates due to duplicate classification and species identification were explored. The fin whale abundance estimate is likely to be underestimated because it excludes unidentified large whales, of which a large proportion was likely to have been fin whales. Notwithstanding this, these large baleen whale abundance estimates are the first robust estimates (corrected for responsive movement and $g(0)$) for this area.

The Group noted that a single platform estimate which would be useful for comparison with earlier surveys had not been performed and encouraged the authors to do so. This would facilitate comparison with the Spanish and Faroese portions of previous NASS, which overlapped with the CODA survey area. Because of the heterogeneity of the methods employed in past surveys it is difficult to infer the direction of trends in population size.

An alternative explanation of the difference in distance measurements between the tracker and primary platforms would be systematic bias by one or both platforms. This feature was also seen in the T-NASS shipboard data, where it was attributed to underestimation of distance by the primary platform. Attractive responsive movement by fin whales is unexpected and was considered very unlikely by some members of the WG. However no firm conclusion on this issue could be reached.

The Group agreed with the authors that the model-based estimates should be preferred because of their higher precision. However they also agreed that the estimate for fin whales is certainly negatively biased because a large (but unknown) proportion of the unidentified large whales estimate is likely composed of fin whales. The Group encouraged the authors to investigate this aspect further to determine whether a more accurate estimate for fin whales could be derived.

**6.1.5 SNESSA**

No new information was available beyond that reported last year. The Group encouraged the timely analysis and reporting of these survey results for all species.

**6.1.6 Combined estimate**

There seem to be no issues of overlap thus the survey results are considered additive. A simple sum of the estimates for CODA, Iceland-Faroe Islands, Greenland and Canada yields a total estimate of 42,119 (CV = 0.15). To this may be added the estimate for the Norwegian survey area in the period 1996-2001 of 6,409 (CV = 0.18) (Øien 2009) and recent estimates from the American eastern seaboard of about 3,000 (Palka, SC/17/AE/O14). All of these estimates are negatively biased to a greater or lesser degree by uncorrected perception, availability and/or other biases. Therefore the total number of fin whales in the North Atlantic must exceed 50,000.

**6.2 Minke whale**

**6.2.1 T-NASS aerial Canada**

For the Canadian portion of the T-NASS survey, there were 144 sightings of minke whales. Too few sightings were made in the Labrador stratum to obtain reliable abundance estimates (four lone minke whales). Analytical methods were the same as those described for fin whales under 6.1.1. Corrections for availability bias have not been completed. Using the MCDS approach the uncorrected abundance estimate for minke whales in the NL portion of the T-NASS was 1,087 (CV = 0.27; 95% CI 642 - 1,840), while in the GSS portion of the T-NASS there were an estimated 1,927 minke whales (CV = 0.21; 95% CI 1,196 - 2,799).

The estimates for the NL strata were corrected for perception bias using a mark-recapture analysis based on replicate sightings data from two platforms (4 replicates from 32 unique sightings) on the right side of the survey aircraft. Using the MRDS approach with point independence, the abundance estimate for minke whales in the NL portion of the T-NASS was 3,748 whales (95% CI 2,214 - 6,345; $g(0)=0.29$).

The Group noted that the estimate for the Scotian shelf and Gulf area is biased for availability and perception, while that for NL is biased for availability. Both of these biases are likely large. Nevertheless these were accepted as valid minimum estimates for the areas. It was suggested that the possibility of correcting for availability bias using the methods employed in SC/17/AE/08 be investigated.

No inference on trends could be made as information on historical abundance for this species is very limited.

**6.2.2 T-NASS shipboard Iceland/Faroe Islands combined with T-NASS extension**

Gunnlaugsson reported on document SC/17/AE/O04 (IWC SC/61/RMP12) which presented analyses of the T-NASS 2007 data from the six vessels operating in the central North Atlantic. Three vessels surveyed using double platform BT methods. Two dedicated cetacean observers searched on each of three other research vessels engaged primarily in other research activities. These vessels are referred to as extension vessels and the intention was for them to extend survey coverage to areas not surveyed by the main sightings survey vessels. One of these vessels made no minke whale sightings on full effort and so the area covered only by this vessel (Southwest) receives zero abundance. Abundance in the coastal Icelandic block was covered by aircraft and was not considered here. The area along the coast of East Greenland and the pack ice edge there, which had the highest densities in the survey area in previous NASS, was poorly covered due to adverse conditions. In total, 30 sightings were made in BT mode and 7 sightings in combined platform mode, that is, during periods when BT mode could not be maintained for logistical reasons. In addition 20 sightings were made in single platform mode, mainly on the extension vessels. There were 24 trials (tracker sightings) of which 4 to 5 were likely duplicates, all at short distances, the primaries duplicating nearly all whales that the trackers saw close to the trackline. An analysis is presented from all the vessels combined. Results from both Point Independence and Full Independence were considered and in both cases *g*(0) was estimated at 0.95; *i.e*., close to 1. Including the combined mode effort as primary effort, contrary to expectation, reduced the estimate of abundance.

The results were tested for bias in distance estimates by the primary platform (naked eye estimates). Multiplying up the primary distances by 1.34 (based on comparison of primary and tracker estimates of distance to immediate duplicates of fin whales) led to estimates that were 11% lower.

Assuming no responsive movement (Point Independence model) and using the extension vessel data only when no dedicated sighting vessel data were available (in block CL) gave an estimate for the NASS-07 survey area of 10,900. Full bootstrap 95% confidence intervals are 6,600-30,000. The estimate for the surveyed part of the Central Area is 11,100 (95% CI 6,400 - 30,600). The Full Independence model estimates were almost three times higher, which implies extreme avoidance of the animals to the sighting vessels. This level of avoidance has not been documented and so the Point Independence model estimates are recommended by the authors. A number of problems were identified in the implementation of the BT method in this survey which most likely introduced negative biases due to incomplete recording or not fully independent recording of the uncertainty/incompatibility in species identification from the platforms. These estimates are not corrected for availability bias and where such estimates exist (*e.g*. from the Norwegian surveys, which have minke whales as the target species) they should be preferred.

The Group found the document to be unclear in a number of areas and noted that it contained obvious errors that made the results difficult to understand. Furthermore the information provided is not sufficient to interpret the methods and the estimates. Therefore the Group could not accept the estimates provided.

It was reiterated that Iceland and the Faroe Islands should provide a simple CDS estimate for these data, uncorrected for *g*(0), recognizing that the data are not sufficient for an estimate of this parameter – this estimate should be kept consistent with earlier estimates for similar surveys in the area (Pike *et al.* 2009). A map of sightings used in the analysis would also be useful for the assessment of the work presented.

No inference on trends could be made as the estimates were not accepted. Nevertheless they are not inconsistent with previous estimates for the area (Pike *et al.* 2009), in which no trends were detected.

Finally, it was noted with regret that this document had been presented to the SC of the IWC without mentioning either NAMMCO or any other partners involved in the organisation of the surveys.

#### 6.2.3 T-NASS aerial Iceland 2007 (choosing best estimate)

The estimates contained in SC/17/AE/O06 were presented last year and have not been revised. Two estimates were developed: one using data from both primary observers, and the other using data only from the primary observer experienced in previous minke whale cue counting surveys. The latter estimate was 42% higher than the former. In 2009 the Scientific Committee asked this Working Group select the estimate which was most suitable for future assessment work.

The Group reiterated that the estimate based only on the single observer for whom duplicate sightings were available was comparable to the 1987 and 2001 estimates. However the estimate using also sightings from the observer for whom data lacked to quantify negative detection bias had a lower CV. Therefore, for assessment purposes, both estimates might be employed.

#### 6.2.4 Aerial Iceland 2009 (survey report)

Pike reported on the Icelandic aerial survey carried out in June-July 2009, which was a continuation of a series of surveys, using nearly identical design and methodology, conducted in 1987, 1995, 2001 and 2007 (Pike *et al.* 2008, 2009). The main target species of these surveys has been minke whale, however sightings of all species are registered. The 2009 survey was carried out primarily because the abundance of minke whales estimated from the 2007 survey was not consistent with earlier surveys: Pike *et al.* (2008) estimated that the abundance of minke whales in 2007 was just 24% of that estimated for 2001 by Borchers *et al.* (2009). Results from a partial survey carried out in 2008 suggested that the 2007 results might be anomalous (Gunnlaugsson *et al.* 2009)

The survey was conducted successfully in June-July 2009. The aircraft, equipment, survey design and observation protocols were nearly identical to those used in recent aerial surveys in the area. One of the primary observers and the cruise leader (control observer) were experienced in minke whale cue counting surveys, while the other primary observer had experience from ship surveys only. Full double platform effort was maintained on one side of the plane only.

Of the 29 days the plane was available, at least some effort was flown on 17 (59%). This was somewhat worse than in 2007, when 67% of the available days were flown. Total realized effort was 73% of planned effort. This is not as good as in 1995, 2001

(78%) or 2007 (79%), but better than that achieved in 1987. In general extensive areas of fog and prevailing northerly winds made surveying particularly difficult in 2009.

The primary observer, who had no prior experience from aerial surveys, performed poorly in recording data quickly enough and produced fewer sightings and was exchanged with the cruise leader (control observer) partway through the survey. In addition, a serious equipment failure led to the loss of some data. This may create some difficulties in the data analysis.

Data compilation and checking are not yet complete so distribution maps and sighting records are as yet unavailable. Generally minke whales were sighted more frequently than in 2007, but probably less frequently than in 2001. It is anticipated that an estimate for minke whales will be completed by January 2010

The Group appreciated that this survey encountered many problems but was pleased that an abundance estimate should be feasible with the data that were collected. It was noted the production of an abundance estimate by January 2010 would be in time to be presented to the scheduled meeting of the Assessment WG.

**6.2.5 T-NASS aerial Greenland**

Hansen presented document SC/17AE/08. The details of the survey are the same as reported under 6.1.3 for the fin whales. Twenty-seven (22 from sea states lower than 3) sightings of minke whale were made within a strip width of 300 m: the average time from first detection to when the sighting passed abeam was 1.7 sec. Due to the uniform and narrow distribution of the detections strip census methods were used to analyze the survey. To correct for whales missed by the observers and whales that were submerged during the passage of the plane two methods were considered.

***Method 1*** included all detections of minke whales (n=27) and correction for an instantaneous availability that included submergence of whales. Using only data from sea states <3 (n=22) the ‘near surface’ (both whales breaking the surface and nearby - visible from the planes on photos) abundance of minke whales was 1,866 (CV = 0.30) and a correction for whales missed by the observers with a simple mark-recapture estimator resulted in a corrected abundance of 1,904 (CV = 0.30) whales. The proportion of time that minke whales were visible (available) to observers was estimated using aerial photographic images collected in Faxafloi Bay in Iceland in September 2003. Adjusting for the availability bias resulted in a fully-corrected estimate of 16,609 (95% CI 7,172 - 38,461) minke whales.

***Method 2*** used only detections of minke whales that were observed to break the surface (n=19). Applying this method to effort data at sea state<3 (n=14) results in an ‘at surface’ abundance of 1,174 (CV = 0.39) whales and correcting for whales missed by the observers increased the abundance to 1,198 (CV = 0.39) whales. Data from satellite transmitters (ST-15, Telonics Inc.) deployed on five minke whales in West Greenland, Svalbard/Norwegian waters and Iceland during 1998-2002) were used to adjust for availability by estimating the proportion of time the whales had their backs above the surface. This resulted in fully corrected estimate of 22,952 (95% CI 7,815-67,403) minke whales.

The Group remarked that both the photos and most of the satellite tag applications used to estimate availability were from areas other than Greenland, and that the corrections should therefore be applied with caution.

The Group noted that the authors had used the average forward sighting distance as the width of the detection window, and suggested that 2 times the average would be more appropriate. Using 2 times the average would reduce the higher (method 2) estimate and thus make the estimates quite similar. In calculating the average forward distance the authors use the larger number from the 2 observers (the lower number being 0 in all cases), which may have been seen as compensating for use of the average distance in the correction for availability bias.

Given a larger detection window (as is the case with most previous surveys), a uniform detection probability within the window is less likely. This in addition to the heterogeneity in the cues implies a positive detection correlation of the 2 observers. The correction for perception bias would therefore be too low.

With these caveats, the Group welcomed the two abundance estimates and noted that they are similar and both equally suitable for management purposes.

From the historical series of point estimates it appears that the general trend in this area is a slight increase, even if it was underlined that the methods used in previous abundance estimates are not all homogeneous.

The group discussed the applicability of these methods to the Icelandic aerial surveys. It was noted that the detection windows of the two sightings platforms used in the Twin Otter differ significantly and the sightings are not concentrated at the abeam line, which would invalidate the application of these methods for those data.

#### 6.2.6 T-NASS shipboard Greenland

The Group regretted that working paper had not been made available for this meeting, however Hansen reported that 27 sightings were collected and the preliminary uncorrected (for both perception and availability bias) abundance estimate is 7,079 animals (CV = 0.35; 95% CI 3,477-14,413). It was recommended that this estimate be fully documented and reported as soon as feasible.

#### 6.2.7 CODA and SCANS II

The abundance of minke whales was estimated from data collected during shipboard sightings surveys as part of the Cetacean Offshore Distribution and Abundance in the European Atlantic (CODA) project using CDS methods because of limited sample size (document SC/17/AE/O01). Sightings were restricted to the northern blocks of the survey area and estimated abundance, uncorrected for $g(0)$ or responsive movement, was 6,765 (CV = 0.99; 95% CI 1,240 - 36,900)). Minke whale abundance was estimated from the SCANS-II survey of European Atlantic continental shelf waters in

2005 using MRDS design-based methods as 18,614 (CV = 0.30; 95% CI 10,400 - 33,200) (document SC/17/AE/O03).

Abundance of minke whales was estimated in 1994 from the SCANS survey as 8,445 (CV = 0.24; 95% CI 5,000 - 13,500) (Hammond *et al.* 2002). The estimate for 2005 for the area covered in 1994 was 13,462 (CV = 0.27); higher, but not significantly at the 5% level, than the 1994 estimate.

#### 6.2.8 SNESSA

See item 6.1.5.

#### 6.2.9 Combined estimate

The presence of an overlap between the Icelandic aerial and shipboard surveys precludes a simple addition of the estimates for this area. Furthermore, it was underlined that the latest Icelandic shipboard estimate has not yet been accepted.

The Group noted that, although the Canadian and Greenlandic aerial surveys had been conducted somewhat later than the others, it was unlikely that there would be movement that would result in double-counting. One indication of the absence of movement between the areas is the lack of minke whale sightings from the simultaneous Redfish survey platforms, implying that there is little movement between Canada and West Greenland or between these areas and areas further east. For these reasons the Group deems the estimates to be additive in this case.

It was noted that the Norwegian mosaic survey total estimate and the other T-NASS estimates cannot be directly added as the Norwegian estimates apply to a 6-year period and are fully corrected for availability and perception biases. Nevertheless the sum of all estimates would provide an absolute minimum number of minke whales in the North Atlantic. This sum would be in excess of 150,000 animals.

### 6.3 Humpback whale

#### 6.3.1 T-NASS aerial Canada

For the Canadian portion survey, there were 227 sightings of humpback whales. No sightings were made in the Labrador stratum. Analytical methods were the same as those described for fin whales described under 6.1.1. Corrections for availability bias have not been completed. Using the MCDS approach the uncorrected abundance estimate for humpback whales in the NL portion was 928 humpback whales (CV = 0.19; 95% CI 634 - 1,357), while in the GSS portion there were an estimated 653 humpback whales (CV = 0.26; 95% CI 385 - 1,032).

The estimates for the NL strata were corrected for perception bias using a mark-recapture analysis based on replicate sightings data from two observers (13 replicates from 88 unique sightings) on the right side of the survey aircraft. Using the MRDS approach with point independence, the abundance estimate for humpback whales in the Newfoundland portion was 3,712 whales (95% CI 2,536 - 5,428; $g(0)$=0.25). Assuming a constant rate of population increase, comparing the 2007 estimates with uncorrected results from Hay's 1981 survey of a smaller portion of Newfoundland waters (Hay

1982), humpback numbers in Newfoundland waters may have increased at approximately 8.2%.

The Group noted that the point estimate presented here was higher than the one from past surveys. However, it was underlined that the extent of this and previous surveys do not exactly coincide and the comparison has to be made with caution, although anecdotal information (*e.g.* from tour operators) seems to confirm an increase in abundance.

The estimates presented were endorsed by the Group. The Group also recommended that the estimates be corrected for availability, while recognizing that such corrections must by necessity be preliminary.

#### 6.3.2 T-NASS aerial Iceland

Pike presented document SC/17/AE/05 which provides estimates of humpback whale abundance from the Icelandic coastal aerial survey conducted in June-July 2007. Details of the survey methods are provided by Pike *et al.* (2008) and NAMMCO (2009). Humpback whale sightings were concentrated off northwest Iceland, and most whales were seen close to the pack ice edge there. Unlike in 1995 and 2001, no humpbacks were seen off eastern Iceland.

Double platform (DP) effort was maintained on one side of the aircraft, data from this side were used to provide correction factors for perception bias for the primary and combined platforms. Four estimates were provided: 2 using conventional distance sampling techniques for the combined platforms and the primary platform, one using the right side DP data and MRDS methods to provide an estimate corrected for perception bias for the primary platform, and one using the same data to provide a similarly corrected estimate for the combined platforms. The conventional estimate using data from both platforms was 1,138 (95% CI 565 - 2,039), while that for the primary platform only was 810 (95% CI 370 - 1,770). Incorporation of a mean $g(0)$ of 0.64 (CV = 0.36) for the primary platform raised that estimate to 1,275 (95% CI 454 - 3,579), and $g(0)$ of 0.88 (CV = 0.64) for the combined platforms increased that estimate to 1,522 (95% CI 802 - 2,887). Post stratification of the survey area to that which was actually covered lowered all these estimates by 19-23%. These estimates are not corrected for whales that were diving and hence not visible as the plane passed over, and are therefore negatively biased.

Total abundance estimated for 2007 using comparable methodology was 52% and 72% lower than 1995 and 2001, respectively (Pike *et al.* 2009), however neither decrease is significant ($P>0.05$).

The Group discussed the different estimate methods presented and considered the Combined Platform Corrected estimate (CP-C) to be the best to date as it includes most observations. However, for consistency with previous estimates, the Primary Platform estimates (PP and PP-C) were also accepted.

Because responsive movement was considered unlikely the Group recommended that the estimates be redone under the assumption of point independence. This was done after the meeting resulting in a *g*(0) value of 0.70 (CV = 0.17) for the primary platform and an abundance estimate of 1,162 (95% CI 497 - 2,717). The combined platform estimate incorporated a *g*(0) of 0.91 (CV = 0.06) for a total abundance of 1,242 (95% CI 632 - 2,445).

The absence of sightings east of Iceland seems to be the major reason for the decline in abundance as indicated by the 2007 estimate.

**6.3.3 T-NASS shipboard Iceland/Faroe Islands**

Pike presented document SC/17/AE/04 which provided abundance estimates for humpback whales from the Icelandic and Faroese components of the T-NASS ship surveys. As in most previous surveys (Pike *et al.* 2005) humpback whales were commonly sighted to the north and northwest of Iceland in blocks IN and NW. Unlike in previous surveys, no humpbacks were sighted off eastern and northeastern Iceland, and few were seen close to East Greenland. Coverage in both these areas was however poor. A combined platform estimate, using conventional distance sampling analysis and non-duplicate sightings from both platforms, totalled 11,572 (95% CI 4,502 - 23,807) for humpbacks identified with high and moderate certainty. Effort conducted in full B-T mode was analyzed using MRDS techniques in Trial configuration and assuming point independence. This resulted in an estimated *g*(0) for the primary platform of 0.79 (CV = 0.12) and an abundance of 16,633 (95% CI 6,494 - 42,601). Adding whales identified with low certainty raised this estimate by 6% for both estimates. The former estimate is uncorrected for perception and availability biases, while the latter is corrected for perception and at least partially for availability. The abundance estimated in 2007 is lower, albeit not significantly so, to those estimated for 1995 and 2001 (Paxton *et al.* 2009), suggesting that the rapid increase in abundance documented by Pike *et al.* (2005, 2009) may have ceased.

The distribution of sightings seems to have changed since 2001 which might be a consequence of appreciable changes in the marine ecosystem around Iceland in recent years (Ástþórsson *et al.* 2007). In particular capelin abundance off Iceland has been lower in recent years, and the summer distribution has shifted towards East Greenland (Pálsson *et al.* 2009) This could explain the absence of sightings off eastern Iceland, however survey effort in this area was sparse.

The analysis does not incorporate effort from the extension vessels, however these vessels made very few sightings of humpback whales so the abundance estimates would not be affected. However it was recommended that the authors should incorporate this effort at least into the map illustrations to show the areas that were covered.

A higher than expected proportion of humpback whale sightings was made while in B-T mode. This has the effect of making the MRDS estimate higher than would be expected by the correction for *g*(0) alone. The reasons for this are not clear but it may simply be related to the clustered distribution of humpbacks. The Group therefore considered the combined CDS analysis to be most reliable, as it relied on a greater amount and wider distribution of survey effort.

The Group further recommended an investigation of the possible presence of responsive movement. If such evidence is found then a MRDS model assuming full independence should be used.

The Group accepted the combined platform estimates as that most consistent with previous estimates and therefore most suitable for assessment purposes.

### 6.3.4 T-NASS aerial-shipboard combined Iceland/Faroe Islands

The combination of the Iceland and Faroe Islands shipboard and aerial results is not straightforward as the survey areas overlap off northern and western Iceland. In addition, most humpbacks were seen off northwestern Iceland and were associated with the pack ice edge there. The ship surveyed this area about 20 days later than the plane, by which time the ice edge had apparently receded to some extent. Thus there is a danger of "double counting" whales that might follow the receding ice edge, even outside the overlap area. The Group agreed that a first approach could be to employ abundance estimates from the shipboard surveys in the overlapping areas and to use the post-stratified aerial survey for the rest.

### 6.3.5 T-NASS aerial Greenland and aerial-shipboard combined

Hansen presented document SC/17/AE/06 which included results of the 2007 aerial survey and an analysis of trends using standardized analyses of past surveys. A total of 21 sightings of humpback groups were collected. The line transect estimate for 2007 was 1,020 (CV = 0.35). When the estimate was corrected for perception bias with mark-recapture distance sampling (MRDS) methods, the abundance increased to 1,528 (CV = 0.50). Correction for availability bias was developed based on time-depth-recorder information on the time spent near the surface (0-4 m). The resulting estimate for 2007 was 3,299 [3] (CV = 0.57; 95% CI 1,170 - 9,301) for the MRDS analysis. An alternative strip census estimate deploying a strip width of 300 m resulted in 995 (CV = 0.33) whales. Correction for perception bias resulted in 991 (CV = 0.35) whales and corrected for the same availability bias as for the MRDS method resulted in a fully-corrected estimate of 2,154 (CV = 0.36; 95% CI 1,087 - 4,270) humpback whales in West Greenland in 2007.

Aerial line transect surveys, which were conducted off West Greenland eight times between 1984 and 2007, were used to estimate the rate of increase on this summer feeding ground. Only the surveys in 1993, 2005, and 2007 gave enough sightings to construct independent density estimates, whereas the surveys in 1987-89 and 1984-85 had to be merged and treated as two surveys. The annual rate of increase was 9.4% $yr^{-1}$ (SE = 0.01) between 1984 and 2007.

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[3] Subsequently a revised estimate 3,272 (CV= 0.5; 95% CI 1,230-8,710) was approved after the meeting.

No estimate from the 2007 ship survey off West Greenland was presented. The Group recommended that this estimate be completed and documented in a timely manner.

The Group noted that there was a low number of sightings for this species and that aerial coverage was poor in the high density Disko Bay area. As the MRDS analysis accounts for the decline in detectability with distance while the strip census does not, the MRDS analysis was preferred and accepted for use in assessment.

It was noted that similar or even higher apparent rates of increase have been observed for this species in other areas, including Iceland (Pike *et al.* 2005, 2009) and Antarctica (Matsuoku *et al.* MS 2004).

**6.3.6 SNESSA**

See item 6.1.5.

**6.3.7 Combined estimate**

As for minke and fin whales the Group considered it unlikely (but not impossible) that there would be movements of humpback whales between survey areas over the course of the surveys. The Group considered that the reviewed abundance estimates are additive once the new estimates for indicated areas are carried out according to the guidelines suggested. Summing the Icelandic/Faroese ship survey, Greenlandic and Canadian estimates results in about 15,000 humpback whales in the Atlantic, however this is an underestimate as it does not include the Northeast Atlantic or the US eastern seaboard, and incorporates several uncorrected negative biases.

### 6.4 Pilot whale

**6.4.1 T-NASS aerial Canada**

For the Canadian portion, there were 53 sightings of pilot whales. Only 10 sightings of 104 animals were made in the NL strata, so abundance could not be estimated there. For the Gulf and Scotian Shelf data, corrections for availability bias have not been completed. Using the MCDS approach the uncorrected abundance estimate for pilot whales in the GSS portion was 6,134 pilot whales (CV = 0.320; 95% CI 2,774 - 10,573). Compared with previous abundance estimates for the Gulf and Newfoundland, there appears to be a negative trend in pilot whale abundance.

The Group noted the indication of an extreme decline in the abundance of this species since the 1981 survey (Hay 1982) which might be correlated with the decline in squid abundance in the area.

**6.4.2 T-NASS shipboard Iceland/Faroe Islands**

Mikkelsen presented document SC/17/AE/13 which included a model-based abundance estimation of pilot whales by fitting a generalized additive model with spatially-referenced covariates to data collected during the 2007 Icelandic (shipboard and aerial) and Faroese (shipboard), as well as the extension (shipboard) components of the T-NASS. Density was estimated in two stages; presence-absence of whales was modelled logistically, then non-zero density was assumed to be constant. The product of the predictions obtained from the two models provided an estimate of abundance.

The spatially-referenced covariates considered were longitude, latitude, depth, sea-surface temperature, and group size as well as survey type. Additionally, *g*(0) was calculated with respect to perception bias and estimates were provided considering presence or absence of responsive movements. Variance was estimated using non-parametric bootstrapping. Design-based distance sampling estimates were provided for comparisons with estimates from previous surveys. Estimates based on the double platform data with additional data from both platforms combined were also made. The authors considered the best estimate over the entire region was from the full-independence model, assuming responsive movements, with additional undistinguished combined effort from both platforms. This estimate was 77,400 (95% CI 44,700 - 181,700).

The Group noted that the previous request from the Assessment Working Group in March 2009 to provide a CDS estimate had not been fulfilled as the design-based estimate provided uses MRDS methods. It reiterated its recommendation to do so for the combined platform data as this is required for comparison to earlier surveys.

Some of the estimates provided have unrealistically wide confidence intervals, sometimes with 0 as a lower bound, which probably results from an inappropriate use of bootstrapping.

The Group considers that this work is not satisfactory in its present form and therefore it cannot assess either the estimates or the trends. Furthermore it urges for the completion of the analysis as the most recent endorsed estimates (from the 1995 and 2001 surveys) lay too far back in time to be used for management purposes. To help with improving the document the Group listed the following additional issues of concern:

- The model-based density maps show evidence of “edge effects” wherein density is unaccountably high at the edge of a stratum.
- The sightings shown in the two maps (Fig.5 and 6) are different and some sightings are apparently missing.

### 6.4.3 Index of relative abundance for NASS-T-NASS surveys

The Group agreed that the closest index to absolute abundance with the data at hand is density calculated from CDS for the blocks that are common to all surveys. Therefore it was suggested that CDS analysis be carried out for a common area for all years and all blocks (post-stratification). It was also deemed useful to analyse the changes in group size between the years. Mikkelsen agreed to pursue this matter.

### 6.4.4 T-NASS aerial Greenland

Hansen presented document SC/17/AE/09 which detailed abundance estimates for pilot whales, harbour porpoises and dolphins. A total of 17 sightings (12 duplicates) of pilot whale groups were collected. The at-surface abundance of pilot whales was 3,253 animals (CV = 0.38; 95% CI 1,495 - 7,078) using MRDS methods, while that using MCDS methods was 2,976 animals (CV = 0.46; 95% CI 1,178 - 7,515). The authors considered the latter estimate to be more robust. Correction for availability bias was developed based on three pilot whales instrumented with satellite transmitters at the

Faroe Isles. Correction of the at-surface abundance with the availability factor (40%) increased the pilot whale abundance in West Greenland to 7,440 (CV = 0.49; 95% CI 3,014 - 18,367). No previous abundance estimates for this species have been made in Greenland.

The Group noted that the MCDS estimate had a surprisingly larger CV than the MRDS one. It was inferred that it must be due to the small sample size as no covariate could explain the variance.

The Group welcomed these results, the first abundance estimate for what is a harvested species in West Greenland. The Group recommended that the authors compare these results with those from past surveys conducted off West Greenland. While abundance estimates from past surveys have not been developed for this species, a comparison of distribution and numbers of sightings would be helpful.

The Group endorsed the MCDS estimate and deemed it acceptable for assessment purposes. The correction for availability derived from satellite tag data assumes that pilot whale pods dive in synchrony, which is not always true. However the correction also assumes that the whales can be seen to a depth of 6 m, which is very optimistic. Hence the group could not reach a conclusion regarding the applicability of this correction.

**6.4.5 CODA**

The abundance of long-finned pilot whales was estimated from data collected during shipboard sightings surveys as part of the CODA project using the MRDS design-based method and also using density surface modelling (SC/17/AE/O09). The best estimate from the design-based method was 25,101 (CV = 0.33; 95% CI 13,250 - 47,550).

There was some evidence of responsive movement for this species, therefore an MRDS model assuming Full Independence was employed in the analyses. However, the Group noted that a CDS estimate would be required for comparison with earlier surveys.

The 2007 estimate will be revisited and may be revised in the future. In addition data from adjacent T-NASS strata will be included in future analyses. The Group therefore decided to await future results which are expected within the next year.

**6.4.6 SNESSA**

See item 6.1.5.

**6.4.7 Combined estimate**

As noted under 6.4.2, a combined estimate for the T-NASS/CODA survey areas will be produced in the coming months. Movement between other survey areas over the course of the surveys was considered unlikely, therefore the estimates should be additive.

**6.5 Harbour porpoise**

**6.5.1 T-NASS aerial Canada**

For the Canadian portion of the T-NASS survey, there were 65 sightings of harbour porpoise with no sightings made in the Labrador stratum. Corrections for availability bias have not been completed. Using the MCDS approach the uncorrected abundance estimate in the NL portion was 958 harbour porpoise (CV = 0.37; 95% CI 470 - 1,954), while in the GSS portion there were an estimated 3,667 harbour porpoise (CV = 0.35; 95% CI 1,565 - 6,566).

The estimates for the Newfoundland strata could not be corrected for perception bias using a mark-recapture analysis because there were no replicate sightings data (24 unique sightings).

The Group agreed that these estimates are severely negatively biased because of uncorrected perception and availability biases. There was no reliable data with which to assess trends in abundance for this species.

**6.5.2 T-NASS aerial Greenland**

A total of 35 sightings (7 duplicates) of harbour porpoises were collected in the 2007 aerial survey (SC/17/AE/09). An MRDS analysis produced an abundance of harbour porpoise of 6,585 animals (CV = 0.34; 95% CI 3,379 - 12,832). Correction for availability bias was developed based on three harbour porpoises instrumented with satellite transmitters in Denmark, making the corrected at-surface abundance with the availability factor (31%) to 21,242 animals (CV = 0.38; 95% CI 10,290 - 43,851). If only data from one side of the plane (with experienced harbour porpoise observers) were used, 31 sightings (7 duplicates) were left. The abundance of harbour porpoise was 10,314 (CV = 0.35; 95% CI 5,193 - 20,484) using MRDS methods (half normal model). Correction of the at-surface abundance with the availability factor (31%) increased the harbour porpoise at-surface abundance to 33,271 (CV = 0.39; 95% CI 15,939 - 69,450). No previous abundance estimates have been made in Greenland.

The Group welcomed this estimate as the first for this species which is harvested in Greenland. It was considered that the one-sided estimate detailed above was the most accurate, as it included almost all the sightings and utilized data from observers highly experience for with this species. This estimate was considered suitable for assessment purposes.

It was suggested that another approach might be to utilize correction factors (incorporating availability and perception) already estimated for these particular observers from SCANS-II and other surveys to provide a corrected estimate for comparison with that derived above. However such an approach might require covariate data that were not collected during the survey.

**6.5.3 SNESSA**

See item 6.1.5.

**6.5.4 SCANS II**

Hammond presented document SC/17/AE/O03 which described how the abundance of harbour porpoise was estimated from the SCANS-II survey of European Atlantic continental shelf waters in 2005 using MRDS design-based methods as 385,617 (CV = 0.20). An estimate for approximately the same area as surveyed in 1994 (project SCANS) was 335,000 (CV = 0.21), very similar to the 1994 estimate of 341,366 animals (CV = 0.14). However, distribution predicted from the model-based analysis showed that animals were distributed further south in 2005 than in 1994.

The abundance of this species seems stable for the SCANS II area: the two design-based estimates are almost identical and the two model-based estimates differ only slightly. However, it is evident that the distribution had changed markedly between the SCANS and SCANS II surveys.

#### <u>6.5.5 Combined estimate</u>

The Group perceived no issues with summing estimates from all areas once they are available.

### 6.6 Dolphin species

#### <u>6.6.1 T-NASS aerial Canada</u>

##### *6.6.1.1 Common dolphins*

For the Canadian portion of the T-NASS survey, there were 228 sightings of common dolphins, Two sightings (16 animals) were made in the Labrador stratum. Corrections for availability bias have not been completed. Using the MCDS approach the uncorrected abundance estimate in the NL portion was only 558 common dolphins (CV = 0.41; 95% CI 253 - 1,233), while in the GSS portion there were an estimated 53,049 common dolphins (CV = 0.21; 95% CI 34,865 - 80,717).

The estimates for the NL strata were corrected for perception bias using a mark-recapture analysis based on replicate sightings data from two observers (6 replicates from 16 unique sightings) on the right side of the survey aircraft. Using the MRDS approach with point independence, the corrected abundance estimate for common dolphins in the Newfoundland portion of the T-NASS was 613 dolphins (95% CI 278 - 1,355; $g(0)=0.91$).

The Group welcomed this new abundance estimate from Canada, the first for this species from such a broad area. As such, trends in abundance for this species cannot be assessed.

##### *6.6.1.2 White-sided dolphins*

There were 120 sightings of white-sided dolphins, of which 1 sighting (4 animals) only was made in the Labrador stratum. Corrections for availability bias have not been completed. Using the MCDS approach the uncorrected abundance estimate for white-sided dolphins in the NL portion was only 1,142 (CV = 0.28; 95% CI 659 - 1,982), while in the GSS portion there were an estimated 4,289 animals (CV = 0.210).

The estimates for the NL strata were corrected for perception bias using a mark-recapture analysis based on replicate sightings data from two observers (9 replicates from 57 unique sightings) on the right side of the survey aircraft. Using the MRDS approach with point independence, the abundance estimate for white-sided dolphins in the Newfoundland portion was 3,086 animals (95% CI 1,781 - 5,357; *g*(0)=0.37).

The abundance of white-sided dolphins in the Gulf of St. Lawrence only in 1995 was estimated to be 11,700 by Kingsley and Reeves (1998), whereas in the following year they were estimated to number only 560. The T-NASS estimate falls between the Gulf of St. Lawrence estimates of the mid-1990's which showed variable numbers between successive years and therefore we could not conclude evidence of a negative or positive trend.

***6.6.1.3 White-beaked dolphins***

There were 85 sightings of white-beaked dolphins, of which none were made in the Labrador stratum. Corrections for availability bias have not been completed. Using the MCDS approach the uncorrected abundance estimate for white-beaked dolphins in the NL portion was only 1,250 white-beaked dolphins (CV = 0.22; 95% CI 691 - 2,260), while in the GSS portion a total of only 17 sightings of this species were made, precluding estimation of abundance.

The estimates for the NL strata were corrected for perception bias using a mark-recapture analysis based on replicate sightings data from two observers (5 replicates from 40 unique sightings) on the right side of the survey aircraft. Using the MRDS approach with point independence, the corrected abundance estimate for white-beaked dolphins in the Newfoundland portion was much larger: 15,625 dolphins (95% CI 8,637 - 28,250; *g*(0)=0.08).

White-beaked dolphins were estimated by Kingsley and Reeves (1998) to number between 2,600 and 2,400 for both 1995 and 1996, respectively, in the Gulf of St. Lawrence. There is an apparent reduction in the Gulf abundance for this species based on the T-NASS compared to those years.

**6.6.2 T-NASS aerial Greenland**

A total of 62 sightings (35 duplicates) of white-beaked dolphins were collected during the Greenlandic survey (SC/17/AE/09). Both MRDS and CDS analyses were performed. The data were truncated at 10% (370 m) for the conventional DS analysis which left 56 sightings for analysis. The abundance of white-beaked dolphins was 9,827 animals (CV = 0.19; 95% CI 6,723 - 14,365) using MRDS methods (with no correction for availability bias). Using MCDS methods the estimate was 9,677 animals (CV = 0.23; 95% CI 6,148 - 15,232). Correction for availability bias was developed based on data from one white-beaked dolphin instrumented with a satellite transmitter in Iceland. This correction (82% available at the surface) increased the white-beaked abundance in West Greenland to 11,801 (CV = 0.23; 95% CI 4,975 – 27,994).

The Group warned that the correction factor applied is based on tagging results from only one animal in a different area, and therefore should be considered preliminary. It was also noted that the variance of the corrected estimate is underestimated as there is no variance estimated for the correction factor Nevertheless this was welcomed as the first abundance estimate for this species in West Greenland.

No trend information was presented at this meeting and the Group recommended that the necessary historical information be presented at the next meeting.

**6.6.3 CODA and SCANS II**

Hammond and Cañadas presented documents SC/17/AE/O02, SC/17/AE/O03 and SC/17/AE/O09 where the abundance of various species of dolphins was estimated from the CODA survey in 2007 and the SCANS-II survey in 2005 in European Atlantic waters. The following table gives the estimates for each species (CV), stating the analysis method used: corrected or uncorrected for *g*(0) and responsive movement; design-based or model based.

| **Species** | **CODA (2007)** | **SCANS-II (2005)** |
|---|---|---|
| Common dolphin | 116,709 (0.34)<br>corrected model-based | 50,506 (CV = 0.29; 95% CI 28,700 - 88,800)<br>corrected design-based |
| Striped dolphin | 67,414 (0.38)<br>corrected model-based | |
| Common and/or striped dolphins | 259,605 (0.37)<br>corrected model-based | 76,374 (CV = 0.25; 95% CI 47,500 -122,800)<br>corrected design-based |
| Bottlenose dolphin | 19,295 (0.25)<br>uncorrected design-based | 12,645 (0.27)<br>uncorrected design-based |
| White-beaked dolphin | | 16,788 (CV = 0.26; 95% CI 10,100 - 27,900)<br>corrected design-based |

The Group noted that the SCANS 1994 estimate for common dolphins is not corrected for responsive movement and thus cannot be used for comparison. For this reason it is not possible to estimate trends for this species. The SCANS-II estimate for white-beaked dolphins in the area surveyed in the 1994 SCANS survey was 10,958 (CV = 0.29), compared to the 1994 estimate of 7,856 (CV = 0.30; 95% CI 4,000 - 13,000) (Hammond *et al.* 2002). There were not enough sightings of bottlenose dolphins for an estimate.

**6.6.4 SNESSA**

See item 6.1.5.

**6.6.5 Combined estimate**

Data are available for white beaked dolphins for T-NASS shipboard and T-NASS Icelandic aerial. The Group encouraged the analysis of these data which is necessary before a combined estimate can be calculated.

## 6.7 Other species

**Sperm whales**

The T-NASS acoustic data from Iceland and the Faroese should be analysed shortly, following a methodological course to be held in Iceland during the fall of 2009.

Hammond presented the results in document SC/17/AE/O09. The abundance of sperm whales was estimated from data collected during shipboard sightings surveys as part CODA project using CDS design-based methods and density surface modelling for visual data and using acoustic data. The best estimates were 2,077 (CV = 0.20) whales from the model-based analysis of the visual data and 2,239 (95% CI: 1,707 - 2,936) whales from the acoustic analysis. The latter estimate does not include block 1 where there were visual sightings.

The Group noted that the estimate using acoustic data is only moderately higher than the visual estimate, suggesting that availability bias is not extreme for this species. The group encouraged further simultaneous visual and acoustic estimates for this species and recommended that this be done with the T-NASS data.

**Beaked whales**

Hammond reported CODA results for beaked whales (document SC/17/AE/O09). The total abundance of 6,992 (95% CI 4,287 - 11,403) was obtained using a design-based uncorrected CDS estimate. Using a model based DSM estimate the abundance of beaked whales was calculated to 7,343 (95% CI 4,075 - 13,230). The acoustic data do not warrant further analysis.

The T-NASS shipboard data include in total 26 sightings of northern bottlenose + 10 unidentified. The Group recommended that these be combined with CODA data for analysis.

The Icelandic aerial survey recorded a few sightings but not enough to produce an estimate for this species.

Canada, SNESSA and Greenland did not record enough sightings for an estimate for either beaked or sperm whales

**Killer whales**

The low number of sightings for this species does not allow abundance estimate calculations (NAMMCO 2009, page 270 for the detailed numbers).

### 6.8 Additional analyses to be carried out

#### 6.8.1 Combined CODA/T-NASS analyses

Hammond informed the Group that he and Cañadas would be reanalysing CODA and SCANS-II data using model-based methods in the next 6 months. The Group considered that this would be an ideal opportunity to undertake integrated model-based analyses of CODA and T-NASS data. The Group considered that most added value could be gained from combined estimates for pilot, minke, fin and sperm whales as well as white-beaked dolphins. The Group tasked Hammond, Desportes and Víkingsson with developing a proposal with costs and sourcing any necessary additional funding to make this happen.

#### 6.8.2 Combined T-NASS/CODA/SNESSA distribution maps and survey report

At the last meeting it was agreed that a primary publication on the planning, conduct and results of the T-NASS and associated surveys, particularly pertaining to general distribution of cetaceans throughout the entire survey area, including the extension areas, would be produced as a priority. Acquarone and Desportes agreed to lead in the development of this document, to be completed and submitted for publication by June 2010 (see 8.1). The Group urged all participants to cooperate fully and promptly with Acquarone in this effort.

**6.8.3 Other species**

***6.8.3.1 Harbour porpoise / T-NASS aerial Iceland***

Analysis of this dataset is in progress and should be completed this year. It is expected that a fully-corrected estimate of abundance will be produced.

***6.8.3.2 T-NASS shipboard Iceland/Faroe Islands – dolphins***

Acquarone agreed to take on this task, and to complete the analysis on a priority basis. The analysis will be done in concert with CODA to the extent possible (see 6.8.1).

***6.8.3.3 T-NASS aerial Iceland – dolphins (wb)***

Víkingsson agreed to try to have analysis of these data completed within the coming year, but noted that it is not a high priority species for Iceland.

## 7. TOWARDS THE NEXT SURVEYS

### 7.1 Methodological questions

**7.1.1 Survey methodologies (e.g. multispecies surveys, synoptic *vs* mosaic survey, double *vs* single platform survey, two independant *vs* top-directed platforms, etc.)**

***Large scale synoptic survey?***

Initial discussion centred on the advantages of a large-scale synoptic survey such as T-NASS over smaller scale national surveys or mosaic surveys, and whether these advantages were worth the costs.

Ideally, any survey should cover the entire seasonal range of the target species/stock. For a multi-species survey, this requires coverage of a very large area. Therefore the geographic scale of the T-NASS and associated surveys was considered its greatest advantage, and this could only be achieved through international coordination.

A synoptic survey also provides a snapshot of distribution that is impossible to achieve with smaller scale or mosaic surveys. Large variations in distribution have been detected in the NASS – T-NASS series, and these may not have been detected using other means. However, over a longer term, mosaic surveys do provide reliable information on temporal changes in distribution.

The main disadvantage to such coordination was perceived to be the cost in time and money of coordinating often disparate national survey groups. In addition, some degree of flexibility is required from all parties, and the agreed survey methods, stratification etc. may not be ideal for every species. On the other hand, some cost savings might be realized through pooling of resources and large scale equipment purchases.

The Group agreed that coordination at least at the level of the T-NASS was desirable and should be pursued for the next round of surveys. It was noted that even more central planning and coordination, as in CODA, had advantages but might not be achievable in a situation where most funding came from national institutes. However, Hammond brought to the attention of the group that CODA was funded by national institutes and government departments and SCANS-II was 50% funded by the EU and 50% by institutes and government departments.

***Methodological issues: Ship surveys***

A detailed evaluation of the methodology used in the T-NASS was provided at the last meeting last year (NAMMCO 2009), so the Group concentrated on more general issues.

Clearly there are issues with the implementation of the B-T mode in mixed species surveys; these were encountered by both T-NASS and CODA. Nevertheless it was considered that something like B-T was required for species that are known to exhibit responsive movement (*e.g.* some dolphins, minke whales, pilot whales, harbour porpoises) and also to detect responsive movement even if it is not suspected. For example, responsive movement by fin whales was detected in CODA, although these results remain uncertain. It was also noted that many of the problems encountered, especially in the T-NASS, could have been overcome by better training and more familiarity with equipment and systems. The Group concluded that having two platforms had proved its worth, but that alternatives to B-T, such as IO or the independent platform B-T used in SNESSA, should be investigated.

Other issues were discussed last year but work on the abundance estimates has only emphasized their importance. These include:

- A better system is needed to address uncertainty in species identification, preferably one that will allow post-classification of uncertain categories;
- A better method of distance estimation is needed for the primary platform. The use of reticule binoculars by primary observers should be considered;
- *Post-hoc* identification of duplicates should be considered in addition to or instead of field identification;
- Better protocols are required for defining and dealing with groups for some species, particularly those that form large dispersed groups such as pilot whales;
- Better, more robust equipment is required. Equipment should be ordered at least a year in advance;
- Pre-cruise training is an absolute necessity and a pilot survey should be considered.

***Methodological issues: Aerial Surveys***

Again a detailed evaluation was provided last year, so only general issues were discussed.

Observer training and experience was considered the most important issue in all areas. For surveys using small planes, such as in Iceland and parts of Canada, it is imperative to use experienced observers from the start, as even one poor observer can jeopardize the entire survey. Moreover it is impossible to evaluate an observer without accumulating some sighting data, which may take some time in low density areas. It has proven difficult to establish and maintain a core of experienced observers for surveys that may happen only infrequently.

Observer training is important but it has proven difficult to train observers in the air, particularly on small planes. Ground training in the plane can be very effective. It was recommended that for any large scale survey, an allocation of survey time up to several days be devoted to training and practice flights. Ideally the latter should be carried out so that observers can acquire a search image for the target species.

The use of specialized harbour porpoise observers in multi-species surveys was discussed but no firm conclusions were reached. Experience in Iceland and Greenland shows that these observers tend to have a very narrow search width and generate fewer sightings of larger whales than other observers. This can result in low precision unless greater effort is applied. On the other hand they appear to miss fewer sightings close to the plane (at least this is a feature of the Greenland data) and thus are less affected by perception bias. If harbour porpoise are a target species, it was considered that special training and experience with this species was required.

Equipment and recording systems were considered adequate in Greenland and Canada, but should be updated for Iceland. Pike agreed to provide recommendations for this. The Greenlandic system is also collecting video and still photographs, and this was considered a useful addition for all areas.

Once again the use of immersion suits by all air crew was recommended.

#### 7.1.2 Analytical methodologies: Model *vs* design based estimates

Because of time constraint, this question was left out to be dealt with at the one day public workshop following the meeting.

### 7.2 Planning (timing, participants, form)

Participants provided their countries' general survey plans to the Group. Canada is now planning to conduct large-scale surveys on a 10 year rotation, which would mean their next survey should be in 2017. However these plans could be flexible if there is opportunity to participate in an international exercise such as T-NASS. Iceland and the Faroe Islands wish to maintain the 6 year rotation established in the NASS, but noted that there could be some flexibility in this. Greenland is planning a large whale survey in 2013.

Hammond informed the Group that the present plan is to conduct SCANS and CODA type survey simultaneously on a roughly 10 year rotation, with the next survey occurring in 2015 at the latest. Large-scale surveys on the US eastern seaboard (*i.e.*

SNESSA) are planned for 2013 and 2017. Norway will continue its mosaic survey programme, with the current rotation ending in 2013.

Given the above, the Group considered the most opportune time for the next large-scale survey would be in the period 2013 to 2015. This will require some flexibility from all partners, and planning should begin as soon as possible. The Group recommended that the NAMMCO Scientific Committee should provide direction and initiate planning and negotiations with survey partners as soon as feasible. This might best be done by establishing a small planning group which would bring in participation from all potential partners.

### 7.3 Other

Nothing was discussed under this item.

## 8. PUBLICATION OF SURVEY RESULTS

### 8.1 Consideration of submission for a special issue?

In 2009 the NAMMCO Scientific Committee recommended that a primary publication on the planning, conduct and results of the T-NASS, particularly pertaining to general distribution of cetaceans throughout the entire survey area, including the extension areas, be produced as a priority. CODA and SNESSA had agreed to participate in this. Noting that Acquarone and Desportes had already agreed to lead in preparing this paper (see 6.8.2), the Group considered that it would be the ideal introduction to a series of papers covering abundance estimates from the survey, preferably published together in a single issue. In this regard the Group noted the offer of Greg Donovan to publish T-NASS papers in a single issue of *J. Cetacean Res. Management*. Working papers reviewed at this meeting could form the basis of this publication.

All participants expressed interest in this proposal. Hammond noted that results from CODA will be published by species, when and where appropriate, but agreed that some CODA papers might be suitable for the proposed joint publication. It was agreed that Acquarone will lead in developing this publication, initially by contacting lead authors for the papers and negotiating a suitable publication agreement. It was also agreed that a deadline of June 2010 would be set for submission of papers for this publication.

## 9. OTHER ITEMS

### 9.1 Presentation(s) for the T-NASS-SNESSA-CODA Workshop on 10 October

The group agreed on dividing the general presentations and the results from the surveys between the participants as follows:
Lawson – welcome and opening remarks, Hammond – general presentation of Scans I-II & CODA, Desportes – general presentation of T-NASS, Pike & Víkingsson – combined results for large baleen whales, Gunlaugsson – combined results for sperm whales, Mikkelsen – combined results for beaked and pilot whales, Hammond – combined results for small cetaceans, Hammond – methodological Issues, Cañadas – model *vs* designed based estimates.

## 10. NEXT MEETING

Given that further results for several species from the T-NASS will be forthcoming, it was recommended that the Group should meet again in about one year's time, at the direction of the Scientific Committee.

## 11. CLOSURE OF MEETING and ADOPTION OF REPORT

On the behalf of NAMMCO, Pike thanked the participants for their work and the Department of Fisheries and Oceans, Quebec, particularly Danielle Baillargeon, for hosting the meeting.

The report was reviewed by correspondence and the final report was agreed upon on 18 January 2010.

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Appendix 1

**AGENDA**

1. CHAIRMAN WELCOME AND OPENING REMARKS
2. ADOPTION OF AGENDA
3. APPOINTMENT OF RAPPORTEURS
4. REVIEW OF AVAILABLE DOCUMENTS AND REPORTS
5. T-NASS DATASET: validation, storage, formats, and availability
6. REVIEW OF ABUNDANCE ESTIMATES AND TRENDS
   - 6.1 Fin whales
     - 6.1.1 T-NASS aerial Canada
     - 6.1.2 T-NASS shipboard Iceland/Faroe Islands
     - 6.1.3 T-NASS aerial Greenland
     - 6.1.4 CODA
     - 6.1.5 SNESSA
     - 6.1.6 Combined estimate
   - 6.2 Minke whales
     - 6.2.1 T-NASS aerial Canada
     - 6.2.2 T-NASS shipboard Iceland/Faroe Islands combined with T-NASS extension
     - 6.2.3 T-NASS aerial Iceland 2007 (choosing best estimate)
     - 6.2.4 Aerial Iceland 2009 (survey report)
     - 6.2.5 T-NASS aerial Greenland
     - 6.2.6 T-NASS shipboard Greenland
     - 6.2.7 CODA / SCANS – SCANS II
     - 6.2.8 SNESSA
     - 6.2.9 Combined estimate
   - 6.3 Humpback whales
     - 6.3.1 T-NASS aerial Canada
     - 6.3.2 T-NASS aerial Iceland
     - 6.3.3 T-NASS shipboard Iceland/Faroe Islands
     - 6.3.4 T-NASS aerial-shipboard combined Iceland/Faroe Islands
     - 6.3.5 T-NASS aerial Greenland and aerial-shipboard combined
     - 6.3.6 SNESSA
     - 6.3.7 Combined estimate
   - 6.4 Pilot whales
     - 6.4.1 T-NASS aerial Canada
     - 6.4.2 T-NASS shipboard Iceland/Faroe Islands
     - 6.4.3 Index of relative abundance for NASS-T-NASS surveys
     - 6.4.4 T-NASS aerial Greenland
     - 6.4.5 CODA
     - 6.4.6 SNESSA
     - 6.4.7 Combined estimate
   - 6.5 Harbour porpoises
     - 6.5.1 T-NASS aerial Canada
     - 6.5.2 T-NASS aerial Greenland
     - 6.5.3 SCANS II

6.5.4 SNESSA
6.5.5 Combined estimate
6.6 Dolphins
6.6.1 T-NASS aerial Canada
6.6.2 T-NASS aerial Greenland – white beaked dolphins
6.6.3 CODA / SCANS II
6.6.4 SNESSA
6.6.5 Combined estimate
6.7 Other species
6.8 Additional analyses to be carried out
6.8.1 Combined CODA/T-NASS analysis
6.8.2 Combined T-NASS/NASS/CODA/SNESSA/SCANS II distribution map and common T-NASS/CODA/SNESSA survey report
6.8.3 Other species
6.8.3.1 Harbour porpoise / T-NASS aerial Iceland
6.8.3.2 T-NASS shipboard Iceland/Faroe Islands- dolphins
6.8.3.3 T-NASS aerial Iceland – dolphins (wb)
7. TOWARDS THE NEXT SURVEYS
7.1 Methodological questions
7.1.1 Survey methodologies (a. o., multispecies surveys, synoptic *vs* mosaic survey, double *vs* single platform survey, two independant vs. top directed platforms, etc.)
7.1.2 Analytical methodologies: Model *vs* design based estimates
7.2 Planning (timing, participants, form)
7.3 Other
8. PUBLICATION OF SURVEY RESULTS
8.1 Consideration of submission for a special issue?
9. OTHER ITEMS
9.1 Presentation(s) for the T-NASS-SNESSA-CODA Workshop on 10 October
10. NEXT MEETING
11. CLOSURE OF MEETING and ADOPTION OF REPORT.

Appendix 2

**LIST OF DOCUMENTS**

| **Doc. No.** | **Agenda** | **Title** |
|---|---|---|
| SC/17/AE/01 | 1 | List of Participants. |
| SC/17/AE/02 | 2 | Draft Agenda. |
| SC/17/AE /03 | 4 | List of Documents. |
| SC/17/AE /04 | 6.3.3, 6.3.4 | Pike *et al.* Estimates of the abundance of humpback whales (*Megaptera novaengliae*) from the T-NASS Icelandic and Faroese ship surveys conducted in 2007. |
| SC/17/AE /05 | 6.3.2, 6.3.4 | Pike *et al.* Distribution and abundance of humpback whales in Icelandic coastal waters in summer 2007. |
| SC/17/AE /06 | 6.3.5 | Heide-Jørgensen *et al.* Rate of increase and current abundance of humpback whales in West Greenland. |
| SC/17/AE /07 | 6.1.4 | Heide-Jørgensen *et al.* Abundance of fin whales in West Greenland in 2007. |
| SC/17/AE /08 | 6.2.5 | Heide-Jørgensen *et al.* Estimates of minke whale abundance in West Greenland in 2007. |
| SC/17/AE /09 | 6.5.2; 6.6.2, 6.44 | Heide-Jørgensen *et al.* Abundance and distribution of long-finned pilot whale, white-beaked dolphin and harbour porpoise from Greenland aerial survey 2007. |
| SC/17/AE /10 | 6.2.4 | Pike *et al.* Cruise report from the 2009 Icelandic CIC aerial survey. |
| SC/17/AE /11 | 6, all sp. | Acquarone *et al.* T-NASS distribution maps. |
| SC/17/AE /12 | 6.1 – 6.7 | Lawson and Gosselin. Distribution And Preliminary Abundance Estimates For Cetaceans Seen During Canada's Marine Megafauna Survey - A Component of the 2007 T-NASS. |
| SC/17/AE /13 | 6.4.2 | Paxton *et al.* Density surface fitting of the T-NASS 2007 Pilot Whale Sightings. |
| SC/17/AE /14 | 6 | Lawson. Perception bias corrections for abundance estimates of cetacean in Newfoundland waters in |

| Doc. No. | Agenda | Title |
|---|---|---|
| | | during the 2007 T-NASS survey. |
| SC/17/AE/O01 | 6.1.5, 6.2.7 | Macleod *et al.* Distribution and Abundance of Fin whales and other baleen whales in the European Atlantic. IWC SC/61/RMP10. |
| SC/17/AE/O02 | 6.6.6 | Cañadas *et al.* Abundance and distribution of common dolphins in the offshore NE Atlantic. IWC SC/61/SM6. |
| SC/17/AE/O03 | 6.2, 6.5, 6.6, 6.8.3 | Hammond *et al.* SCANS II final report. |
| SC/17/AE/O04 | 6.2.2 | Paxton *et al.* Mark-Recapture Distance Sampling Estimate of Minke Whales from the Icelandic, Faroese and Russian components of T-NASS. IWC SC/61/RMP12. |
| SC/17/AE/O05 | 7 | NAMMCO SC/15/10 - Report of the NAMMCO SC Working Group on Abundance Estimates, Copenhagen, 8 April 2008. |
| SC/17/AE/O06 | 6.2.3 | Pike *et al.* T-NASS Icelandic aerial survey: Survey report and a preliminary abundance estimate for minke whales. IWC SC/60/PFI 12. |
| SC/17/AE/O07 | 6.1.2 | Pike *et al.* Estimates of the abundance of fin whales (*Balaenoptera physalus*) from the T-NASS Icelandic and Faroese ship surveys conducted in 2007. IWC SC/60/PFI 13-revised. |
| SC/17/AE/O08 | 7 | NAMMCO SC/15/09 - Report of the NAMMCO SC Working Group on T-NASS, Copenhagen, 7 April 2008. |
| SC/17/AE/O09 | 7 + CODA rel. | Hammond *et al.* CODA final report. |
| SC/17/AE/O10 | 6.2 | Bøthun *et al.* Abundance of minke whales in the Northeast Atlantic based on survey data collected over the period 2002-2007. IWC SC/61/RMP 2. |
| SC/17/AE/O11 | 6.2 | Lindstrøm *et al.* Modelling multi-species interactions in the Barents Sea ecosystem with special emphasis on minke whales and their interactions with cod, herring and capelin. Deep Sea Research II 56. |

| Doc. No. | Agenda | Title |
|---|---|---|
| | | |
| SC/17/AE/O12 | | NAMMCO SC/10/8 - Report of the NAMMCO SC WG on Abundance Estimates – 2002. |
| SC/17/AE/O13 | | NAMMCO SC/11/9 - Report of the NAMMCO SC WG on Abundance Estimates – 2003. |
| SC/17/AE/O14 | 6, all SNESSA rel. | Palka. Abundance estimate of cetaceans in the US Northwest Atlantic from 1995 to 2006; I. Aerial data. NAMMCO SC/15/AE8 (this draft document was updated with some results from the 2007 survey for the Quebec City NAMMCO workshop). |
| SC/17/AE/O15 | 6, all SNESSA rel. | Palka. DRAFT - PRELIMINARY - Abundance estimate of cetaceans in the Northwest Atlantic from 2007; I. Shipboard data. SC/15/AE9. 36 pp. |

ANNEX 2

# REPORT OF THE NAMMCO SCIENTIFIC COMMITTEE WORKING GROUP ON WALRUS - STOCK STATUS OF WALRUS IN GREENLAND AND ADJACENT SEAS

Greenland Representation in Copenhagen, Denmark
23-26 November 2009

## 1. OPENING REMARKS

Scientific Secretary Acquarone welcomed the delegates to the meeting (Section 5.8) on behalf of NAMMCO and communicated some practical details and instructions about the meeting.

Working Group (WG) Chair Born reminded the delegates that this forum's purpose it to address the following requests for advice from the NAMMCO Council (NAMMCO 15, 16 and 17):

**Ongoing request for advice: R-2.6.3 (NAMMCO/15-2006).**
The Scientific Committee (SC) was asked to provide advice on the 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.

**Ongoing request for advice: R-2.6.4 (NAMMCO/16-2007).**
The SC was requested to provide a formal assessment of the Davis Strait (walrus) stock as soon as finalization of the catch series is complete and the results from the planned 2007 survey are available. The SC was then requested to provide estimate of sustainable yields for the North Water and West Greenland stocks of walrus.

**Ongoing request for advice: R-2.6.5 (NAMMCO/17-2008).**
The SC was requested to provide a full assessment of the North Water, West Greenland-Eastern Baffin Island and East Greenland (walrus) stocks.

It was agreed that the meeting would be chaired by Ugarte.

## 2. ADOPTION OF AGENDA

The Draft Agenda (Appendix 1) was adopted with minor changes.

## 3. APPOINTMENT OF RAPPORTEURS

Acquarone was appointed as *rapporteur* with the assistance of Lockyer and other delegates as required.

## 4. REVIEW OF AVAILABLE DOCUMENTS

Documents that were made available for the meeting are listed in Appendix 2.

The walrus WG was satisfied to note that since the last meeting of the NAMMCO walrus WG in Copenhagen in February 2005 intensified research efforts by Greenland and neighbouring Canada and Svalbard (Norway) has resulted in a wealth of new information on stock structure distribution and abundance of walruses in these three countries.

## 5. STOCK STRUCTURE

### 5.1 Genetic information

The walrus WG agreed on a revised stock structure for walrus in Greenland and Canada based on new, though still limited, data becoming available since its last meeting in 2005.

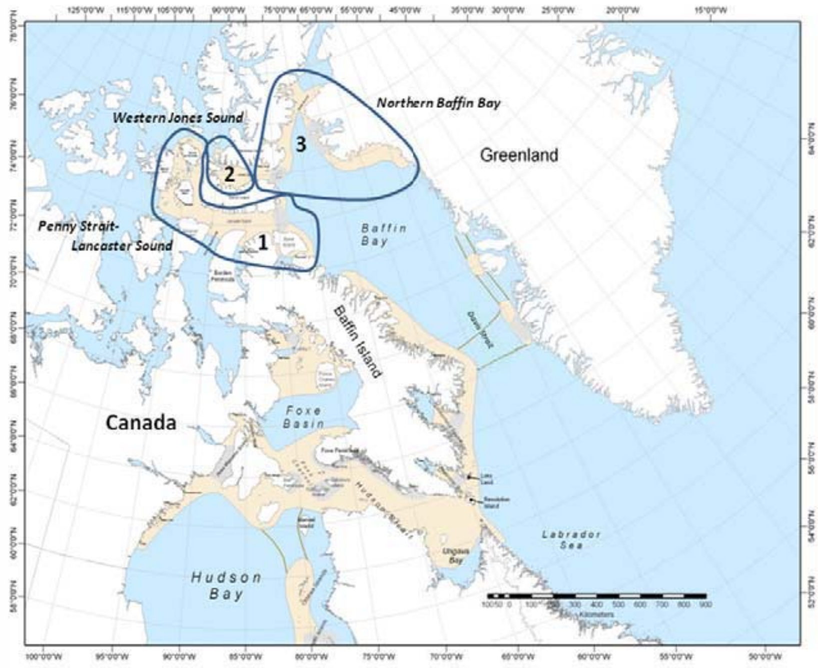


**Fig. 1.** Distribution of Atlantic walruses in the Canadian Arctic and West and Northwest Greenland. The subdivision of the former Northwater (NOW) stock into three stocks is indicated. Known wintering grounds are shown in darker shading.

Stewart provided a general overview of the new adjusted stock divisions in Canada and Northwest Greenland. From a management perspective walruses in the North Water Polynya (NOW) in northern Baffin Bay and the Canadian High Arctic are best treated as 3 stocks given our current state of knowledge: 1) Penny Strait – Lancaster Sound; 2) western Jones Sound; and 3) northern Baffin Bay (BB), Fig. 1. There is a connection between West Greenland and Southeast Baffin Island which indicates a single stock resides in this area. The Hudson Strait stock is also linked to this complex to at least a limited degree. In East Greenland walruses are mainly concentrated north of 73°30´ N and there is little evidence of a connection with the Svalbard – Franz Josef Land walruses. This latter stock is believed to be separate from the stocks further south and east in the Russian waters of Novaya Zemlya, Pechora and Kara seas.

The WG recognized that the evidence for the subdivision of the former "North Water stock" into 3 sub-units was based on limited data; no new data were available at the meeting regarding the connectivity among these northern groups. The WG agreed that according to the most recent information the division of stocks outlined above is the most reasonable.

To explain data in support of the updated stock division, Andersen presented a genetic analysis that tested the suggested connection between walruses in West Greenland and S.E. Baffin Island (Canada). To determine the relationship between walruses in these two areas a genetic analysis (based on 17 microsatellite markers from a total of 345 samples) including recent samples from West Greenland, Southeast Baffin Island (Canada) , Hudson Strait (Canada), and Northwest Greenland (i.e. from the Baffin Bay stock) (SC/17/WWG/06). Results indicated (1) that walruses at Baffin Island and West Greenland do not differ genetically, (2) that walruses from Hudson Strait have some genetic input to this Southeast Baffin Island-West Greenland complex, and (3) the hypothesis of a fourth group of walruses in the Baffin Island-West Greenland complex from an unknown local; the demographical identity of this fourth group could not be explained based on the existing material.

The WG welcomed this thorough study and noted the novel information that will be useful for management purposes, particularly with respect to the West Greenland – Southeast Baffin walruses, which must be considered one population. However, it was also noted that the current state of knowledge does not permit exact quantification of the rates of influx from one area to the other. It was also noted that there is a very limited male-mediated influx into the Baffin Bay stock from southern areas and a potential sub-structuring of the Baffin Bay stock. The latitude of the boundary between the Baffin Bay and West Greenland stocks cannot be defined genetically because of a lack of tissue samples from the areas between Central West Greenland and the Qaanaaq area of N.W. Greenland (Ummannaq and Upernavik).

Born and Lydersen informed the WG about the results of document SC/17/WWG/O11 which proposes that the Laptev walrus should be considered the westernmost population of Pacific walrus, not a nominate subspecies.

The WG commented that this study is based on very few, badly preserved bone samples, which is unfortunately the only Laptev walrus material currently available to science, and recommended that this issue be revisited when new, more abundant and better samples are available.

### 5.2 Satellite tracking

Dietz presented document SC/17/WWG/10 which described satellite telemetry studies conducted between 2005 and 2008 when 31 walruses were tagged at their wintering grounds near the Store Hellefiske Banke, Central West Greenland (n=23) and at their summering grounds on the coast of Southeast Baffin Island, Canada (n=8). The walruses were monitored for a total of 1,029 days and tracked for 22,142 km. The investigation documented movement of animals between West Greenland and Southeastern Baffin Island; 8 of the transmitters lasted long enough to show seasonal migrations across the northern Davis Strait from Greenland to Canada. The walruses left the Store Hellefiske Banke area in the beginning of May (range: 29 April to 17 May) and it took on average 7 days to cross the ca. 400 km across the Davis Strait. The migration routes were quite similar and took place at the most shallow and the narrowest part of the strait. In addition, one flipper tag deployed on a male walrus on Southeastern Baffin Island 3 September 2007 was recovered from Greenlandic hunters that killed the animal on Store Hellefiske Banke (67.21$^o$N 55.2$^o$W) on 24 April 2009, documenting a migration in reverse of that shown by the satellite tracking. Some sexual segregation was observed with males generally being located further from shore, in denser ice, over greater depths. Futhermore, males appeared to have a larger home range than females during spring along the coast of West Greenland. During autumn, dispersal along the Southeastern Baffin Island coast was more condensed and the sexual segregation was even more pronounced. Again the males occurred further from shore, in waters of greater depths and had a larger home range than females during this season. A connection between male walruses north and south of Cumberland Sound on Southeastern Baffin Island was documented. The spring migration towards Canada is generally linked to the retreat of the pack ice edge. However, the presence of walruses on Store Hellefiske Banke during winter was more related to water depth and access to food than the location of the ice edge or the density of the ice in the area at a given time.

The WG noted that this study confirmed the information from the genetic study that established a link between the West Greenland and Southeast Baffin Island animals and that there is a possibility of a limited movement of individuals northwards from West Greenland. It also confirmed that the animals north and south of Cumberland Sound belong to the same stock and that there is a difference between males and females in preferred habitat and movement as also indicated by local resource users in Canada and Greenland. Born noted that the walruses stayed in the Store Hellefiske Banke area regardless of the ice conditions and added that the continuous decrease of ice in this area likely will make the walruses more available to the walrus hunters.

The ensuing discussion focussed on technology, analysis methods and new possibilities for tagging studies. In this context Lydersen presented document SC/17/WWG/O07 in which the authors report the first year-round data on movement patterns of walruses in the High Arctic, including at-sea positions. Using first-passage times (FPT) to study habitat use, and quantifying habitat selection using mixed-effects Cox proportional hazards models, the study dispelled the conventional perception that seasonal movement patterns of Atlantic walruses are simply a result of them following the retraction and expansion of annually formed sea ice. Walruses in this study (n = 17 males) actively moved into areas of high ice concentration (>90%) during winter; travelling far into the ice pack, as far as 600 km from ice-free water. Additionally, high inter-annual, seasonal site fidelity was documented. Seasonal differences in habitat use patterns were also observed. In summer, when walruses feed intensively, FPTs were affected by water depth and distance to the coast ($R^2 = 0.571$), but these variables had no effect on walrus habitat use in winter. Sea ice concentration was the most important environmental condition during the winter season ($R^2 = 0.162$), though there are clearly other factors influencing where individuals occur in winter that are unaccounted for in these analyses. The male walruses in this study did not do much benthic diving during winter, suggesting that they did not feed often during the time that they are known to breed. Instead, they remained in areas with high ice coverage, far from their coastal summering areas, spending much of their time hauled out or in surface waters.

This information was welcomed by the WG and it was noted that this study presented a very useful method for measuring behavioural parameters such as habitat intensity use and fidelity to feeding (and perhaps also breeding areas).

Jay reported on the multi-year walrus tagging programme conducted in Alaska and east of Russia, speculating on the various tag longevities recorded in this study. While holding a number of confounding variables that may affect tag longevity constant, several effects seemed apparent. These include: 1) an anchor effect on longevity for large tags; 2) deployment region effect on tag longevity, which may reflect a temperature or ice-type effect; and 3) shelf-life of tags on their deployment longevity.

This information was considered very useful by the WG; these findings were generally similar to results from the Greenland-based tagging efforts. Dietz noted that tag longevity on females was about double that on males. Additional information on tag longevity is included in document SC/17/WWG10. It was also noted that in Greenland tags put out on animals located on ice or in the water have a shorter life than those that are put out at haul-outs on land. This might be explained by the fact that it is easier to attach the tags while working in a stable, terrestrial environment as opposed to on unstable pack-ice, but, the diving behaviour of walruses in areas of dense ice where the animals frequently scratch their backs against the ice when diving may also play a role.

### 5.3 Tissue signatures (pollutants, trace elements, *etc.*)

No new information relevant to this theme was presented at the WG meeting.

### 5.4 Other information

Document SC/17/WWG/O5 included information on the historical sex ratio of walruses in Svalbard. Lydersen informed the WG that the authors developed a discriminant function based on measurements of known-sex mandibles of walruses from the Canadian Arctic collected between 1983 and 1998 and used it to explore the sex ratio within walrus catches in Tusenøyane, in south-eastern Svalbard, during the nineteenth century. Canadian mandibles older than 5 years of age of known sex were classified into correct sex groupings with 100% accuracy by using two measurements. Applying the same discriminant function to 80 mandibles from Svalbard older than 5 years of age, resulted in 48 (60%) being classified as males and 32 (40%) as females. The same function was also used to classify a set of 584 (aged and un-aged) mandibles from Svalbard - 67% (390) were classified as males and 33% (194) as females. Eight of the aged jaws (10%) and 41 (7%) of the un-aged jaws had probabilities of classification into the correct sex group of <80%. The authors stressed the importance of being cautious in applying a discriminant function developed from Canadian mandibles to classify the sex of old weathered mandibles from Svalbard. However, they believe their results indicate that female walrus were once more common in southeastern Svalbard than they are now.

### 5.5 Management units

In document SC/17/WWG/O09 Stewart explained that current management units in Canada are based on a comprehensive review and a stock assessment completed in the mid 1990s. Between 1993 and 2004, satellite-linked tags provided information on the movements of walrus in Canada's High Arctic. These data were incorporated with other information that has become available since 1995 to reassess walrus management units in Canada. Tagging data and other information suggest that some finer discrimination of walrus populations is needed as a precautionary approach and to formulate testable hypotheses. Specifically, the previous North Water walrus stock may be considered to be three stocks: Baffin Bay, west Jones Sound, and Penny Strait-Lancaster Sound stocks. The Foxe Basin population appears to be comprised of two stocks (North Foxe Basin and Central Foxe Basin) rather than one. Previously suspected subdivisions in the Hudson Bay-Davis Strait population are substantiated by isotopic evidence although sampling on a finer geographic scale is required before this stock can be partitioned in a formal sense. Evidence from organochlorine and to some extend heavy metal, as well as lead isotope and trace element concentrations support the previously postulated separation of the walrus in the Southern and Eastern Hudson Bay stock from all others.

The WG agreed with the basic conclusions of this paper and underlined that there is further evidence presented above that the West Greenland – Southeast Baffin Island stocks cannot be separated and that there is likely some connection between them and the Hudson Strait stocks.

Along the same lines, but on the Greenland side, it seems that nothing disproves previous indications of a possible limited male gene flow between West and Northwest Greenland, but for management purposes "Southeastern Baffin Island-West Greenland" and "Baffin Bay" should be considered as two separate stocks.

In East Greenland neither the genetics nor the movements of walruses tracked with satellite transmitters during late July-late November 2009 lead the WG to change its conclusion that walruses in East Greenland constitute a demographically and geographically separate stock that has very limited exchange with walruses at Svalbard –Franz Josef Land.

## 6. BIOLOGICAL PARAMETERS

### 6.1 Age estimation

Lydersen presented information from the study reported in document SC/17/WWG/O12 in which the fatty acid composition of the outer blubber of walruses was significantly correlated with tusk volume as a proxy for age.

The WG noted that this is a promising method to be developed and validated.

### 6.2 Reproductive rates

No new information was presented to the WG.

### 6.3 Other parameters

No new information was presented to the WG.

## 7. CATCH STATISTICS

### 7.1 Reported catch

Stewart presented document SC/17/WWG/13 where the reported catch from Nunavut (Canada) was summarised. Walrus harvest data in Nunavut are inconsistent and based on rough estimates for cultural and administrative reasons. The data that are recorded are at best a rough estimate, though it can be concluded that they are unlikely to be overestimates.

The WG agreed with the author that the data presented are of little scientific use and noted that the document does not present any data about struck and lost animals.

Born reported that the Agency of Fisheries, Hunting and Agriculture (AFHA) of the Greenland Government provided the catch statistics for 1993-2008 (SC/17/WWG/14). According to AFHA all catch data from 1993-2004 have been checked and data from 2005-2008 reported in the reporting system “Piniarneq” have been cross-checked with data in the special reporting forms to be filled-out by the hunters and delivered after each walrus catch. This validation of the data since 2005 has been carried out by the AFHA with telephone interviews with each individual walrus hunter. Only one walrus was reported “struck-and-lost” in the reporting period between 2006 (when quotas were introduced) and 2008. Ugarte informed the WG that because of the implausibility of this figure for “struck and lost” the AFHA decided to reduce the walrus quota for West Greenland by 30% for 2009.

Born also commented that there seems to be an apparent decrease in the catch. The reason for the apparent decline in catch numbers could be the occurrence of errors (multiple reporting of individual kills) in the reporting during the early years of enforcement of the “Piniarneq”-system. However, the trend in the figures has not been investigated for correlation with the numbers of active specialized walrus hunters. Born also said that according to an interview survey conducted in Northwest Greenland in 2006 general changes in climate with milder and shorter winters and an earlier ice break-up has recently changed the timing of the hunt in Northwest Greenland. The winter and spring hunts have been difficult or impossible to enact because of poor ice conditions. Early hunting attempts might also have encouraged the walruses to move westward earlier than usual, out of the areas close to Greenland toward Canadian waters along Ellesmere Island. Stewart suggested it is not possible to detect changes in the catch from the Grise Fjord community, because annual catch numbers are typically low and catches are only reported once per year; changes in abundance and timing of arrival of the walruses could have passed undetected.

The WG complimented Greenland for having introduced a quota system for hunting of walrus and for improving its catch reporting system. However, it also underlined the need for the WG to receive detailed information on the performance of the new reporting system to be able to assess variability for, among other purposes, improving the population modelling. Greenlandic catch data are collected by the Agency of Fisheries, Hunting and Agriculture (for a general description see document SC/17/WWG/O02). It was noted that an in-depth explanation of these systems would be very beneficial to the working of this WG and recommended that for the next meeting detailed information be made available by the AFHA on the process of validating reporting of landed catch and "struck-and-lost".

### 7.2 "Struck and lost"

Born reported that in Greenland there is likely a small loss of struck animals during the winter hunt in the Qaanaaq area of NW Greenland. This hunt is performed on thin, new ice and from the ice edge so animals are typically harpooned before being shot. Conversely there is likely a larger loss of struck animals in the spring to fall hunt in this area and further south in West Greenland which is performed from boats that venture into the ice. During this hunt the animals are often shot from a distance before being harpooned and this inevitably results in a larger risk to lose a struck animal.

The WG reiterated the importance of gathering reliable "struck-and-lost" data and expressed its concern that the existing reporting in Canada and Greenland is not working satisfactorily in this regard.

### 7.3 Histories by management units

It was noted that, as far as the Canadian hunt is concerned, the historical hunt data included in studies ranges back to 1977 (see document SC/17/WWG/05). For the settlement of Grise Fjord, which was founded in the mid 1950's, the catch history is obviously limited in time.

The WG encouraged further attempts to retrieve data on past removals from all possible sources.

### 7.4 Other information

Ugarte reported that in 2006 new walrus hunting regulations were introduced in Greenland. In these regulations adult females as well as young and calves in the company of their mothers are totally protected in all areas except in Qaanaaq in NW Greenland, where it is legal to take both adult females and young due to the great economical and cultural importance of walruses for the hunting community in this area. Furthermore, all walruses irrespective of age or sex are totally protected.

## 8. ABUNDANCE AND TRENDS

### 8.1 Recent estimates

***East Greenland*** (SC/17/WWG/07)

Born reported that a geographically and genetically distinct stock of Atlantic walrus is found in East Greenland. This population has its main distribution north of 73°30'N.

To determine the abundance of walruses in East Greenland, visual aerial surveys were conducted between 74ºN and 81º45'N during 12-19 August 2009. The surveys were designed as a combination of total counts of walruses at terrestrial haul-outs and a systematic line-transect survey between 80º21'and 81º24'N in the Northeast Water (NEW) area. During the surveys, the walruses were observed on land in five places on the coast between 74º39'N and 80º01'N but were absent from three traditionally used haul-outs (Sandøen in Young Sund, Port Arthur and Lille Snenæs in Dove Bugt). Females and young walruses were found in the NEW area whereas males were distributed between 75º00'N and 76º36'N confirming previous information that walruses are sexually segregated during this time of the year. Data on "haul-out" and "at surface" activity obtained from eight adult male walruses that were monitored with satellite-linked transmitters in the area simultaneous with the aerial surveys were used to correct estimates of abundance for walruses that were not hauled out during the surveys. The corrected estimate of walruses in their prime distribution area in East Greenland in 2009 was 1,429 (95% CI: 616-3,316); Table 1. There are some reasons to believe that this may be a slight underestimate (see below), so the survey indicates that the East Greenland stock probably numbers at least 1,500 walruses.

The authors noted that if there was an offshore component of walruses south of 77°N, only hauled out on ice, these animals might have been missed in the survey efforts. It was also pointed out that the tags were applied only to adult males, thus there is a lack of information on sub-adults and females. However, due to the high degree of gregariousness in walruses there was no reason to believe that sub-adults have different haulout behaviour or utilize other haulouts than the adult component of the population. However, it was suspected that adult females with young that haul out on ice may exhibit different haulout behaviour from adult males. Therefore, a haulout correction factor established on the behaviour of three walruses including a female that only hauled out on ice in the Kane Basin region in August 2009 was used for correcting the estimate of abundance of females and young in the NEW area. Weather, a factor shown to influence walrus haulout behaviour in other studies, was found not to influence haulout patterns during the study in East Greenland in 2009 because of little variability in the weather during surveys (similar to the situation observed during surveys in Svalbard).

The WG welcomed this abundance estimate, which is the first of its kind for the area, but also recognized that the results may be negatively biased and therefore the stock size is likely higher.

The reason for a potential negative bias is that despite the fact that the aerial surveys concentrated in main distribution areas it cannot be excluded that there were walruses in areas not covered by the surveys (in particular south of the survey area) that were not accounted for by the correction factors.

| Stock | Year | Season | N (number) | cv | 95% CI |
|---|---|---|---|---|---|
| East Greenland | 2009 | August | 1429 | 0.45 | 616-3316 |
| Penny Strait-Lancaster Sound | 2009 | August | 2010 | 0.18 | 1416-2852 |
| Western Jones Sound | 2008 | August | 1415 | 0.18 | 997-2008 |
| Baffin Bay | 2009 | August | 1616 | 0.32 | 876-2980 |
| | 2009 | May | 2676 | 0.32 | 1140-4920 |
| West Greenland-SE Baffin Island (West Greenland only) | 2006 | March-April | 2791 | 0.54 | 1036-7522 |
| | 2008 | April | 3240 | 0.76 | 863-12170 |
| West Greenland-SE Baffin Island (SE Baffin Island only)[1)] | 2007 | September | 1056 | - | - |
| Svalbard | 2006 | August | 2629 | - | 2318-2998 |
| 1) Not corrected for walruses that were not present on land during the boat-count at terrestrial haulouts. | | | | | |

**Table 1:** Recent estimates of abundance (with coefficient of variation, CV, and 95% confidence intervals, CI) of various stocks of walruses in Greenland and neighbouring Canada and Svalbard. The estimates of abundance for the "East Greenland", "Baffin Bay" (May and August 2009) and "West Greenland only" (2006 and 2008) stocks were used in the assessment of walruses in Greenland waters.

***Canadian High Arctic*** (SC/17/WWG/11)
Stewart reported results from aerial surveys in the Canadian High Arctic to estimate the minimum number of walrus alive in the Penny Strait-Lancaster Sound (PS-LS) and West Jones Sound (WJS) stocks that began in 1998. The best recent estimates are derived from surveys in 2007, 2008 and 2009. The maximum count for PS-LS was obtained in 2009 when 557 walruses were counted on 22 haulouts. The maximum count of WJS walrus (401) was obtained in 2008 at 8 of the 9 known haulouts. If adjusting these counts with a factor for walruses not present on the haulouts during the survey the resulting estimates of walruses in PS-LS was approximately 2,010 (95% CI: 1,416-2,852) and 1,450 (95% CI: 997-2,008) in WJS, respectively; Table 1. These estimates should, however, be viewed with caution until better data on the area specific estimates of haulout times, frequency, duration, and independence of hauling behaviour are available for these regions and seasons.

The WG accepted the estimates and agreed with the recommendation to use caution in the use of these figures.

***Baffin Bay stock during summer*** (SC/17/WWG/08)
Born reported that a group of Atlantic walrus – the Baffin Bay (BB) stock - is found year round in the North Water polynya area (NOW) between N.W. Greenland and eastern Ellesmere Island. During summer the eastern parts of the NOW area are virtually devoid of walruses and at this time of year they can be found along the coast and in the fjords of eastern Ellesmere Island (Canada). To determine the abundance of BB walruses in the NOW area during summer, aerial surveys were conducted on 9 and 20 August 2009 over main concentration areas between 78°35' and 80°11'N along eastern Ellesmere Island. Walruses were observed on the ice and in water primarily in the Buchanan Bay and Princess Marie Bay areas. Data on haulout and at-surface activity obtained from three walruses (1 F, 2 M) that were monitored with satellite-linked transmitters in the area, simultaneous with the aerial surveys, were used to adjust estimates of abundance for walruses that were not hauled out or were not at the

water surface during the surveys. Adjusting for animals that were not hauled out at the time of the survey, the estimate of abundance of the BB stock in the NOW area during August 2009 is 1,616 (95% CI: 876--2,980), Table 1. An alternative estimate based on a correction of walruses that were not at the water surface during the survey is 1,233 walruses. The surveys did not cover all potential walrus summering habitat along eastern Ellesmere Island. Hence, these estimates of abundance suggest that at least 1,500 walruses summered in the NOW area during 2009.

The WG discussed the adequacy of the survey design, wherein (1) the survey plane followed the coast line ca. 400 m from the coast and therefore walruses that occurred far from the coast in the broad inlets of Buchanan Bay and Princess Marie may have been missed, and (2) incomplete coverage of all potential summering habitats along eastern Ellesmere Island took place. The authors responded that (1) the survey concentrated on the known summer concentration area, and (2) during the surveys the walruses were observed hauled out on or near fields of ice. During August 2009 there was generally little ice, and it was felt that ice floes would have been spotted from far away if they had been present. The count presented was accepted by the WG as a minimum estimate and the corrected estimate as a likely underestimate of the number of walruses in the northern Baffin Bay area during summer.

***Baffin Bay stock in the North Water area during late winter*** (SC/17/WWG/09)
Hansen presented information based on SC/17/WWG/09 on an aerial survey conducted in late May 2009 in northern Baffin Bay to estimate the abundance of walrus, narwhal and beluga in the North Water area during late winter. During the survey period there was an unusually large proportion of open water in the North Water region. The survey area (54,819 km2) was subdivided into ten strata where 5,423 km were searched. A Twin-Otter with four observers was used for the survey with four individual observer platforms allowing the data to be collected using a mark-recapture approach. A total of 26 sightings of walruses were collected (5 on ice and 21 in water). Data were analyzed by using the Chapman estimator for walruses on ice and a strip transect census method for walruses in water. The two abundance estimates were added and then corrected for availability at the surface. The availability correction factor was obtained by using the dry time (17%) for the saltwater switch of three walruses tagged with satellite-linked radio transmitters in the area in the second half of July 2009. The total abundance was 2,676 animals (95% CI 1,140 – 4,920), Table 1.

The WG discussed the factor used for correcting for walruses submerged and some expressed concern that the instruments used to collect data on “at-surface” time (a dry salt water switch) underestimate the proportion of time a walrus is visible at the surface. Thus, the estimate of abundance may be over-estimated to an unknown extend. It was considered likely that walruses can be observed from an aircraft at 0-2m depth whereas the instruments used for collecting at surface data in this study records time dry at 0 m. It was noted by Born that the depth to which a walrus can be detected from an aircraft inevitably is a function of its distance from the trackline and that in his personal experience only walruses directly below the aircraft are likely to be detected if they are not at the surface. Hansen said that during the aerial surveys of the North Water no walruses had been observed below the surface. Witting commented that even when a walrus is at the surface it is not certain that this necessarily, at all times, results in a “dry” reading recorded by the salt water switch.

The WG recommended that an evaluation of time with a dry salt water switch (i.e. at 0 m, at surface) and time spend between 0 and 2 m be made based on data from other studies and suggested that such an analysis may allow for an evaluation of the degree of potential positive bias in abundance estimates, and for a correction of the estimate. Because of uncertainty of how far down in the water column a walrus can be observed from an aircraft and because some studies indicate that walruses may spend 12-29% of the time visible at the surface during different behaviours (documents SC/17/WWG/O18 and SC/17/WWG/O19) the WG did not have a better “at-surface” estimate than the 17% and its associated variance. Jay suggested that this be accepted as the best estimate of surface time in this study. This was accepted by the WG.

Furthermore, the WG made a request for a revision of the aerial survey taking the instantaneous correction into effect. Born informed the WG that given the fact that walruses usually spend more than 1 minute at the surface when breathing the effect of not including this correction is likely minimal.

In conclusion, the WG could not accept the 2,676 (95% CI: 1140-4,920) estimate above as a “stand-alone” abundance estimate, but could, for assessment purposes at this meeting accept that it was used together with the August 2009 estimate of 1,600 walruses. The latter estimate was considered to be negatively biased whereas the estimate of 2,676 for reasons given above may be positively biased.

***Central West Greenland winter***

Born presented SC/17/WWG/04. Between 21 March and 19 April 2006 and between 3 and 12 April 2008, two visual aerial surveys were conducted to estimate the number of walruses on two disjunct Central West Greenland wintering grounds: the southern wintering ground between ca. 66º30' and ca. 68º15'N and the northern wintering ground between 69º15' and 70º30'N, respectively. The surveys resulted in abundance estimates that were corrected for (1) the availability of walruses on sea ice based on data collected simultaneously with the aerial surveys, (2) walruses submerged below a detectability threshold, and (3) walruses that were missed by the observers.

To obtain correction factors to include walruses that were not hauled out or were submerged during the surveys satellite, tags were deployed on walruses prior to the surveys at the Store Hellefiske Banke off the town of Sisimiut. Five tags were placed in March 2006, and 7 were deployed in April 2008.

Two methods of calculating abundance were utilized:

***Method I*** applied separate adjustments for walruses detected on ice and walruses detected in water. The fully corrected estimates of abundance of walruses corrected for walruses not on ice were 3,196 (CV =0.62) for 2006 and 1,505 (CV =0.41) for 2008. If correcting for walruses in water and adding the estimate of those in the ice the estimates became 3,127 (CV =0.62) in 2006 and 1,806 (CV =0.62) in 2008.

***Method II*** considered all walruses within 350 m from the flight track whether at the water surface or on ice to be equably available for detection and therefore applied a 1-step correction for walruses not available for detection. The estimates of abundance were 2,791 (95% CI: 1,036-7,522) for 2006 and 3,240 (95% CI: 863-12,170) for 2008, Table 1.

After discussion of the results, the WG considered that Method II was the most appropriate because it has fewer assumptions and fewer corrections for walruses that were not at the water surface and does not depend on corrections based on data on the diving activity of only one animal from another area.

For the assessment it was suggested that it was appropriate to use both years. It was also recommended that the estimates be revised to include corrections for instantaneous availability bias, and to examine the problem of potentially underestimating the amount of time in the surface using salt water switch data. However, as this survey is based on walruses seen both in the water and on ice, the influence of the latter factor will be smaller in this survey compared to the spring Baffin Bay survey. It was the opinion of the WG that these corrections would result in only a minor change of the abundance estimates and therefore the estimates based on Method II were accepted for the assessment.

***Southeastern Baffin Island*** (SC/17/WWG/12)
Stewart reported that to support management objectives in Canada and Greenland, the Department of Fisheries and Oceans (DFO, Canada) and Greenland Institute of Natural Resources (GNIR) began a joint research programme in 2005. Aerial surveys were conducted during 2005, 2006, 2007 and 2008. In 2007, a boat-based survey was also conducted in connection with a tagging operation. Direct counts were used to determine the minimum number of animals alive in summer on the southeast coast of Baffin Island. Aerial surveys spanned the coast from roughly the Saddleback Island (62°10'N 68°01'W) in northern Hudson Strait to Isabella Bay (69°37'N 67°33’W) on eastern Baffin Island but concentrated on the area between Loks Land (62°26’N 64°38’W) and Cape Dyer (66°37’N 61°16’W).

The maximum count of 1,056 was obtained on 3-4 September 2007 during boat surveys carried out at only two haul-outs. This count of the minimum number of walruses alive may be adjusted for animals at sea. However, time and site specific data were not available during the meeting to allow for such an adjustment. Furthermore, due to incomplete survey coverage of the potential summer range of walruses in the eastern Baffin Island area, there was uncertainty about the actual number of walruses present in the region. For these reasons the WG was not in a position to estimate the number of walruses in eastern Baffin Island. The WG recommended that the count of walruses obtained during the boat and aerial surveys in 2005-2008 be adjusted for walruses not present at the haul-outs during the surveys.

Given the present state of knowledge it is impossible to know what fraction of animals are subject to hunting from both Canada and Greenland in the shared West Greenland-

Baffin Island stock. However, based on satellite telemetry and genetic information it is reasonable to assume that most animals from West Greenland move to Canada at the end of the winter.

Born informed the WG that a discussion with Witting and Dietz about calculation of corrections factors resulted in the conclusion that the current estimates of correction factors and their associated CVs are acceptable for calculation of estimates of abundance that can be used for assessment of stocks except for Southeastern Baffin Island. The WG concurred with this conclusion and accepted the calculations of the correction factors. The WG was of the opinion that an in-depth analysis including the effects of weather should be made on area-specific activity data before a final estimate of abundance of walruses in Southeast Baffin Island can be derived at. The WG also decided that for modelling purposes a preliminary corrected estimate of 3,030 (CV=0.20) for SEB could be used for assessment. This correction was based on the fact that several studies indicate that walruses in general are hauled out for about one third of the time.

***Svalbard***

Lydersen presented document SC/17/WWG/O06 in which all known terrestrial haul-out sites for walruses in Svalbard (n = 79) were surveyed during the period 1–3 August 2006, when the area was free of ice, and sites that were in use (n = 17) were documented using digital photography. A total of 657 walruses were counted on land in the resultant images. An extensive behavioural data set from walruses equipped with satellite relay data loggers, covering August 2002 to August 2005, was used to account for walruses that were in the water. The proportion of walruses at sea during the survey was calculated to be 0.750 on the basis of 28 thirty-day periods from 23 male walruses during the month of August. Time of day and wind chill did not significantly affect haul-out behaviour. However, a logistic regression model revealed both a correlation among haul-out patterns of individuals within years, and a year effect ($\chi 2 = 6.42$, df = 2, $p = 0.04$). Because the survey was not flown in a year when satellite tags were deployed, the interannual variance was retained in a model (with no other explanatory variables). The overdispersion parameter from this model was 2.02 (deviance = 28.33, df = 14). Thus, variance in proportions of time individuals spent at sea was multiplied by this parameter to achieve a corrected SE around the estimate. The 95% CI based on this SE corresponded to a proportion of walruses at sea during the survey between 0.717 and 0.781, resulting in an estimated total number of walruses in Svalbard in August 2006 of 2,629 (95% CI: 2,318– 2,998).

The WG accepted the survey results for the Svalbard component of the Svalbard-Franz Josef Land population and recommended that in the future the whole distribution area of this stock be included in the survey plans.

In a presentation on estimating the size of the Pacific walrus population during a collaborative U.S.-Russia spring survey in 2006, Jay explained that there had been four previous fall surveys between 1975-1990, but that these did not account for correction factors such as animals in the water and were very imprecise. The Bering Sea was partitioned into survey blocks, and a systematic random sample of transects within a subset of the blocks was surveyed with airborne thermal scanners using standard strip-transect methodology. Counts of walruses in photographed groups were used to model the relation between thermal signatures and the number of walruses in groups, which was used to estimate the number of walruses in groups that were detected by the scanner but not photographed. The study modelled the probability of thermally detecting various-sized walrus groups to estimate the number of walruses in groups undetected by the scanner. Data from radio-tagged walruses were used to adjust on-ice estimates to account for walruses in the water during the survey. The number of Pacific walruses within the surveyed area was estimated at 129,000 with 95% confidence limits of 55,000 to 507,000 individuals. Unlike previous surveys, the 2006 survey provided an accurate enumeration of hauled out walruses from high resolution thermal imagery, very extensive coverage of the survey area, quantification of haul-out behaviour, an adjustment for walruses in water, and a valid estimate of precision.

The WG thanked the presenter and appreciated the huge effort put into this scale of survey and especially development of the application of the IR technique.

### 8.2 Trends in abundance by management units

***Central West Greenland winter*** (SC/17/WWG/04)
Born continued with the presentation of document SC/17/WWG/04. Trends in abundance since the early 1980s were reflected in sighting rates (*i.e.* weighted estimates of density of walruses observed per linear km flown) during 11 aerial surveys conducted over the two wintering grounds - northern and southern wintering grounds - in Central West Greenland in 1981, 1982, 1984, 1990, 1991, 1993, 1994, 1998, 1999, 2006 and 2008. During the years when surveys were made, different airplanes and survey heights were flown.

Satellite telemetry and conventional tagging indicate a connection between these two areas. Furthermore, the trend analysis indicated a connection and inverse relationship between the two wintering areas: When encounter rate was high in the north, it was lower in the south and vice versa. Combining sighting rates in the two areas indicated a declining trend but this was not statistically significant. In conclusion, it was unclear if trends in abundance could be detected from these index series due to the heterogeneity in survey methodologies during 1981-2008 and the large amount of between year variation in the index.

The WG commended the authors for responding to the previous request to investigate the possibility of extracting information on trends from survey data. There were enquiries about correlations between survey results and survey platform. From 1990 the survey techniques was improved considerably involving aircrafts with bubble windows and later double observer platforms.

The WG concluded that despite the commendable effort there are no reliable data to provide new information on abundance trends. Therefore, this WG could not at the moment provide sufficiently robust trend data to improve management processes.

### 8.3 Future survey plans

***Norway***

A complete Svalbard-Franz Josef Land stock survey, including satellite tracking, aerial surveys and genetics, is planned within the Russian Norwegian Environment Commission. Field operations are planned to run 2011-2013 with reporting in 2014.

***Greenland***

A survey to determine late winter distribution and abundance of marine mammals including the Baffin Bay walrus stock in the North Water is planned for 2010. In West Greenland a multispecies winter survey to determine the distribution and abundance of beluga, narwhal, bowhead whale and walrus is planned for 2012.

For Northeast Greenland a survey is planned for 2010 to sample skin biopsies for genetic identification of individual walruses from as many places and individuals as possible in order to detect trends in abundance and shifts in distribution. Samples from 2010 will be compared with analysed samples collected in East Greenland in 2002 an 2003.

A hunter interview survey, including questions on abundance, trends *etc.* is planned for 2010.

***Canada***

The surveys (aerial and boat) in the next few years will be concentrated in the Foxe Basin area.

## 9. ECOLOGY

### 9.1 Diet and consumption

No new information relevant to this theme was presented at the WG meeting.

### 9.2 Impact of global warming

The WG agrees that documented sea ice declines in the Arctic, and escalating predictions for continued declines into the future, raise concerns for all ice-associated pinnipeds in the High North. It is possible that walruses restricted to terrestrial haulouts for a much longer ice-free season might experience increased calf mortality rates, due to stampedes of the herd and predation from polar bears, and a lower overall carrying capacity of the environment due to restrictions imposed by distance between available haulout sites and potential foraging areas. This latter issue may already be a reality for Pacific walruses. Additional concerns arise from uncertainties related to future levels of walrus-prey production from changes in the timing and duration of ice free waters, ocean acidification from increased absorption of atmospheric $CO_2$, and walruses' reduced accessibility to areas containing dense ice-cover that currently serve as refugia from human hunting pressure.

### 9.3 Pollution

No new information relevant to this theme was presented at the WG meeting.

### 9.4 Effects of disturbance

(See item 12.)

### 9.5 Other

No new information relevant to this theme was presented at the WG meeting.

## 10. ASSESSMENT BY STOCK

### 10.1 Present status

Witting and co-authors (SC/17/WWG/05) used recent abundance estimates, historical catches and an age- and sex-structured population dynamic model with density regulation to perform Bayesian assessments of the three populations of Atlantic walrus that occur in Greenland. The estimates of status presented here are comparable with an earlier assessment (document SC/17/WWG/O03) for the East Greenland population only. Owing primarily to updated abundance estimates, but also to an improved abundance prior, their estimates of current status have improved greatly for the West Greenland-S.E. Baffin Island and the Baffin Bay stocks since the assessment in 2005.

*West Greenland- S.E. Baffin Island stock*

The model for this stock is based on the 2006 and 2008 abundance estimates for West Greenland, the minimum count from Baffin Island in 2007 corrected with a general availability factor of 0.30 (cv=0.20), and the trend index estimates from the southern winter area in West Greenland. It applies all West Greenland catches south of the Qaanaaq area in NW Greenland plus Canadian catches after 1977 from settlements of Qikiqtarjuaq, Iqaluit and Pangnirtung on S.E. Baffin Island. It uses the reported catches as a minimum estimate of the total removal, and reported catches plus losses up to 30% as an estimated maximum for the total removal. For future removals, it assumes that 68% are females, as estimated from genetic samples collected from the West Greenland hunt in 2006 and 2007. It also investigates the sustainability of future removals should it be possible to reduce the fraction of females in the catch to 20%, Table 2.

The assessment estimates that the West Greenland- S.E. Baffin Island stock of walrus declined from a carrying capacity of 9,000 (90% CI:5,900-14,000) walruses in 1900 to an abundance of 3,200 (90% CI:1,790–5,430) individuals in 1960, after which time the population has been relatively stable with a local maximum of 4,500 (90% CI:3,650-5,550) walruses in 1993 and a lower 2010 abundance of 3,200 (90% CI:2,300-4,400). This estimates a 2010 depletion ratio of 0.33 (90% CI:0.19-0.60) relative to the pre-exploitation level in 1900, and a yearly replacement of 130 (90% CI:61-190) individuals.

***Baffin Bay stock in the North Water polynya area***

The model for this stock is based on the spring and summer abundance estimates from 2009. It applies the projected historical and recent reported catches from Qaanaaq, as well as Canadian catches after 1977 from Grise Fjord in Jones Sound. It uses the reported or estimated catches as a minimum estimate of the total removal, and reported or estimated catches plus losses up to 30% as an estimated maximum for the total removal. For future removals, it assumes that 50% are females, and it investigates the sustainability of future removals should it be possible to reduce the fraction of females in the catch to 20%, Table 2.

The Baffin Bay stock is projected to have declined almost linearly from an estimated carrying capacity of 10,000 (90% CI: 6,900-16,000) individuals in 1900, to an abundance of 2,100 (90% CI: 1,500-3,100) walruses in 2010. The population is predicted to have a 2010 depletion ratio of 0.20 (90% CI: 0.11-0.33) relative to pre-exploitation level in 1900 with a yearly replacement yield of 84 (90% CI: 31-140). The estimate of current depletion for the Baffin Bay stock, however, is more uncertain than the estimates for the two other stocks owing to the great uncertainty about historical catches from this stock.

***East Greenland stock***

The model for this stock is based on the abundance estimate from 2009, and reported catches since 1889. It uses the reported or estimated catches as a minimum estimate of the total removal, and reported catches plus losses up to 30% as an estimated maximum for the total removal. The fraction of females in future catches is assumed to be only 10%, as estimated from the catch, based on samples from E Greenland.

The assessment model for East Greenland walruses estimate a population that declined from a carrying capacity of 1,600 (90% CI:1,000-2,500) individuals in 1889 to a maximal depletion of 0.73 (90% CI:0.48-0.91) in 1909. Since this time the population is thought to have increased slowly and steadily to an estimated depletion ratio of 0.96 (90% CI: 0.80-0.99) in 2010 with a corresponding abundance of 1,500 (90% CI: 940-2,400) individuals. Given the low depletion, the current yearly replacement yield is also low [12 (90% CI: 10-16)].

### 10.2 Sustainable harvest levels and Management recommendations

Instead of providing management advice based on a fixed probability of increase, the WG has agreed that it is more appropriate to forward a table with a range of options and let managers set the preferred balance between risk and removal levels of walruses.

***West Greenland-S.E. Baffin Island***

Table 2 shows the total annual removals that will allow the West Greenland- S.E. Baffin Island stock to increase with estimated probabilities from 50 to 95%, given a female fraction in the removals of either 68 or 20%. The WG recommends that future total removals be set for an assumed female fraction of 68%, given an acceptable protection level larger than or equal to 70% (numbers in bold). Advice based on a more male biased removal can only be given once it is proven that the actual removals are more male biased.

| | W Greenland-SE Baffin Isl. | | Baffin Bay | | E Greenland |
|---|---|---|---|---|---|
| Probability | FF: 0.68 | FF: =0.20 | FF: 0.50 | FF: =.20 | FF: 0.10 |
| 0.50 | 108 | 154 | 83 | 108 | 26 |
| 0.60 | 100 | 141 | 75 | 98 | 23 |
| ***0.70*** | ***89*** | 129 | ***68*** | 87 | ***20*** |
| ***0.80*** | ***79*** | 115 | ***57*** | 74 | ***17*** |
| ***0.90*** | ***65*** | 95 | ***45*** | 58 | ***14*** |
| ***0.95*** | ***53*** | 80 | ***35*** | 45 | ***12*** |

**Table 2:** Estimated total removals that have a probability of 0.50 to 95% of being sustainable. (*FF = female fraction in the removals*).

***Baffin Bay stock***
Table 2 shows shows the total annual removals that will allow the Baffin Bay stock to increase with estimated probabilities from 50 to 95%, given a female fraction in the removals of either 50 or 20%. The WG recommends that future total removals be set for an assumed female fraction of 50%, given an acceptable protection level larger than or equal to 70% (numbers in bold). Advice based on a more male biased removal can only be given once it is proven that the actual removals are male biased.

***East Greenland stock***
Table 2 shows shows the total annual removals that will allow the East Greenland stock to increase with estimated probabilities from 50 to 95%, given a female fraction in the removals of 10%. The WG recommends that future total removals be set for an acceptable protection level larger than or equal to 70% (numbers in bold).

***General recommendations***
The WG recommends that:

- Total removals for all areas should be set under consideration of a probability of population increase higher than or equal to 70%.
- Mechanisms for validating reporting of catch and loss both for Greenland and for Canada be designed and enforced.
- Managers consider establishing a more robust system for monitoring the sex and age composition of the catch (i.e. through collection of tissue samples from the catch).
- For the West, East Greenland and Baffin Bay stocks, the catches and losses (including the Canadian ones) and the future development of the population be monitored both in light of total removals and in light of climate change and planned industrial development.
- A common management regime be established between Greenland and Canada on shared stocks of walruses.

## 11. NEW TECHNOLOGY and SURVEY METHODS

No new information relevant to this theme was presented at the WG meeting.

## 12. EFFECTS OF HUMAN DISTURBANCE

Boertmann reported that off shore oil exploration is rapidly increasing in Greenland, due to political wishes and optimistic assessments of oil reserves (documents SC/17/WWG/O13 – 17). Within the Greenland range of walrus, licences have been granted in the sea west of Disko Bay (including the important winter habitat on Store Hellefiskebanke and West Disko Island), a licensing round will be carried out for explorations blocks in the eastern Baffin Bay in 2010, and the Greenland Sea is under preparation for a licensing round. The National Environmental Research Institute and Greenland Institute of Natural Resources have prepared Strategic Environmental Impact Assessments (SEIA) for these three areas, as a part of the preparation to the licensing rounds. The major concerns in relation to walrus in Greenland are disturbance and accidental oil spills. The preliminary SEIA conclude that: (1) walruses in the Disko West area are not likely to be impacted by exploration activities (only in summer and autumn) as there will be no temporal overlap, while during development and production there is a risk of displacement from critical habitats. In the Baffin Bay area the risk of temporal overlap of exploration activities and the occurrence of walrus is limited, while development and production activities potentially may pose a major risk for long-term population impacts. The situation in the Greenland Sea is somewhat different as there will be a temporal overlap in the occurrence of walrus and both exploration and exploitation activities, and there will be a major risk of long-term population impacts.

The WG thanked Boertmann for providing this overview.

There are no data available in relation to the effects of disturbance on walrus from activities related to oil exploration and particularly development and production. Another data gap is the potential effects of inhalation oil vapours where walrus and other marine mammals in ice covered waters are forced to surface in oil spills.

Lydersen presented the haul-out monitoring system that used time-lapse cameras, currently in place at selected locations in Svalbard, to monitor potential impacts of tourist visitation. From these cameras it is possible to retrieve information on the use of the haul-out by the walruses and of the presence of humans or other possible sources of disturbance (*e.g.* polar bears). The project is on-going and data have not yet been analysed.

The WG thanked Lydersen and considered this a very valid and interesting approach not only for investigating disturbance on land but also on haul-out usage over time.

## 13. RECOMMENDATIONS FOR RESEARCH

The WG recommends:

***Stock structure:***

- research for improving understanding of stock delineation, such as studies based on samples to be collected from South and North of Cumberland Peninsula, between Central-West and Northwest Greenland, the entrance to Jones and Lancaster Sounds, and in the Laptev, Kara and Pechora Seas.

***Biological parameters:***

- collecting samples that would allow for the determination of the age structure and reproductive capacity of the stocks.

***Catch statistics:***

- research towards the estimation of struck and lost walruses.
- tissue samples from all catches be collected and genetically sexed in order to estimate accurate sex-ratios in the catches for assessment models.

***Abundance estimates:***

- reviewing correction factors for submerged walruses.
- reviewing the estimates of variance in correction factors for walruses not hauled out.

***Assessments:***

- reviewing the effects in the modelling of applying lower and upper limits of historical catches.
- improving understanding of historical catches.

***Ecology and conservation:***

- more studies on anthropogenic disturbance (including fisheries, oil exploration and tourism).
- research efforts be directed to monitoring population abundance, distribution, and age structure in relation to climate change as well as documenting ecological responses by walruses to changing environmental conditions. Future assessment models could incorporate physical environmental parameters into modelling efforts.

## 14. OTHER BUSINESS

Alvarez made a recommendation to improve the structure of the overall assessment model. Such improvement includes modifications to both the population and statistical components of the model. The population model can be extended by modifying the survival parameters such that the reported catch is not directly subtracted from the predicted animals but computed as a predicted catch estimating parameters of hunting mortality and catchability. Those parameters are then inserted as components of a total survival parameter. The structure of the survival modelled in this way is log linear with multiple effects. This structure allows the separation of different hunting methods and the addition of other factors that may affect walrus mortality. To modify the population model in this way, the data requirement would be a time series of effort specific for each group of hunters that have in common a similar hunting method per stock. It is acknowledged that obtaining effort data could appear as a difficult task, but the approach already taken to back calculate catch for the Baffin Bay stock is recommended as a reasonable and accessible way to obtain these data. The parameter of catchability (the efficiency of a particular group of hunters on a stock) will determine the total kill (reported and unreported). To account for the unreported kill, a likelihood component is added to the statistical component of the model that confronts the reported kill (biased) with the catch predicted by the model. The prediction is modified by a bias parameter that is estimated inside the model. This bias parameter will be an estimate of the proportion of animals in the total kill that are reported (quality of the catch record). Sources of information (natural or human related) that are considered to influence the fate of the stock should be discussed and planned for future treatment.

Additional information that would improve the efficiency of the model is age data obtained during surveys. These data can be in the form of age aggregated classes so that the statistical model can confront these data with predictions from the model.

The WG thanked Alvarez for his presentations and recognised that it would be interesting if it was possible to include information on hunting effort into modelling efforts. Born noted that collection of effort data from the walrus hunt in Greenland in a systematic and representative fashion would be major challenge because the hunt is conducted over a large area by many different hunters that operate on many different days during the year. Alvarez was of the opinion that there is a potential to use this method to reconstruct past catch based on proxies for effort, such as number of male hunter at a given time. Stewart mentioned that some useful data might be available for Canadian populations.

## 15. ADOPTION OF REPORT

This report was adopted in a preliminary form at the end of the meeting on 26 November 2009. The final version adopted by correspondence on 4 December 2009.

Appendix 1

**AGENDA**

1. OPENING REMARKS
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3. APPOINTMENT OF RAPPORTEURS
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   - 5.2 Satellite tracking
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7. CATCH STATISTICS
   - 7.1 Reported catch
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   - 7.3 Histories by management units
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8. ABUNDANCE AND TRENDS
   - 8.1 Recent estimates
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11. NEW TECHNOLOGY and SURVEY METHODS
12. EFFECTS OF HUMAN DISTURBANCE
13. RECOMMENDATIONS FOR RESEARCH
14. OTHER BUSINESS
15. ADOPTION OF REPORT.

Appendix 2

## LIST OF DOCUMENTS

| Document no | Agend a item | Title |
|---|---|---|
| SC/17/WWG/00 | | Practical arrangements. |
| SC/17/WWG/01 | 1 | List of Participants. |
| SC/17/WWG/02 | 2 | Draft Agenda. |
| SC/17/WWG/03 | 4 | List of Documents. |
| SC/17/WWG/04 | 8.1, 8.2 | Heide-Jørgensen, M.P., Born, E.W., Laidre, K.L., Fossette, S., Hansen, R.G., Dietz, R., Rasmussen, M. and Stern, H. Abundance and trends in abundance of the Atlantic walrus (*Odobenus rosmarus rosmarus*) in Central West Greenland. |
| SC/17/WWG/05 | 10 | Witting, L., Born, E. W. and Stewart, R.E.A. A reassessment of Greenland walrus populations. |
| SC/17/WWG/06 | 5.1 | Andersen, L.W., Born, E.W., Stewart, R.E.A., Dietz, R., Doidge, D.W. and Lanthier, C. A genetic comparison of West Greenland and Baffin Island (Canada) walruses: management implications. |
| SC/17/WWG/07 | 8.1 | Born, E.W., Boertmann, D.M., Heide-Jørgensen, M.P., Dietz, R., Witting. L., Kyhn, L., Riget, F.F., Laidre, K. and Ugarte, F. Abundance of Atlantic Walrus (*Odobenus rosmarus rosmarus*) in East Greenland. |
| SC/17/WWG/08 | 8.1 | Born, E.W., Stewart, R.E.A., Dietz, R., Heide-Jørgensen, M.P., Villum Jensen, M., Fossette, S., Laidre, K., Knutsen, L.Ø. and Riget, F.F. Abundance of the Baffin Bay population of Atlantic walrus (*Odobenus rosmarus rosmarus*) during summer 2009. |
| SC/17/WWG/09 | | Heide-Jørgensen, M.P., Burt, M.L., Hansen, R.G., Born, E.W. and Rasmussen M. The significance of the North Water to whales and walruses. |
| SC/17/WWG/10 | 5.2 | Dietz, R., Born, E.W., Stewart, R.E.A., Heide-Jørgensen, M.P., Toudal, L., Lanthier, C., Villum Jensen, M. and Teilmann, J. Movements of walruses (*Odobenus rosmarus*) tracked with satellite transmitters between Central West Greenland and Southeast Baffin Island 2005-2008. |
| SC/17/WWG/11 | 8 | Stewart, R.E.A., Born, E.W. and Dunn, J.B. Minimum population estimates for walrus in the Penny Strait/Lancaster Sound and West Jones Sound stocks, Canada. |
| SC/17/WWG/12 | 8 | Stewart, R.E.A., Born, E.W:, Dietz, R. and Ryan, A.K. Estimates of minimum population size for walrus around Southeast Baffin Island |

| | | |
|---|---|---|
| SC/17/WWG/13 | 7.1 | Currie, A. Walrus Data From Nunavut and Nunavik, 2003/4-2008/9. |
| SC/17/WWG/14 | 7.1 | Born. Greenland catch statistics reported from the Department of Fisheries, Hunt and Agriculture. |
| SC/17/WWG/O01 | 9.2, 12 | Born, E.W. (2005). An assessment of the effects of hunting and climate on walruses in Greenland. *Dr. Philos. Thesis.* |
| SC/17/WWG/O02 | 7.1 | Born, E.W. and Ugarte, F. (2007). Letter to Ministry of Environment and Nature. |
| SC/17/WWG/O03 | 10 | Witting, L. and Born, E.W. (2005). Assessment of Greenland walrus populations. *ICES J. Mar. Sci.* 62:266-284. |
| SC/17/WWG/O04 | 9.3 | Wolkers, H., van Bavel, B., Ericson, I., Skoglund, E., Kovacs, K.M. and Lydersen C. (2006). Congener-specific accumulation and patterns of chlorinated and brominated contaminants in adult male walruses from Svalbard,Norway: Indications for individual-specific prey selection. *Sci. Total Environ.* 370:70-79. |
| SC/17/WWG/O05 | 5.4, 6.3, 8.1 | Wiig, Ø., Born, E.W., Gjertz, I., Lydersen, C. and Stewart, R.E.A. (2007). Historical sex-specific distribution of Atlantic walrus (*Odobenus rosmarus rosmarus*) in Svalbard assessed by mandible measurements. *Polar Biol.* 31:69-75. |
| SC/17/WWG/O06 | 8.1 | Lydersen, C., Aars, J. and Kovacs, K.M. (2008). Estimating the number of walruses in svalbard from aerial surveys and behavioural data from satellite telemetry. *Arctic* 61(2):119-128. |
| SC/17/WWG/O07 | 9, 5.2 | Freitas, C., Kovacs, K.M., Ims, R.A., Fedak, M.A. and Lydersen, C. (2009). Deep into the ice: over-wintering and habitat selection in male Atlantic walruses. *Mar. Ecol. Prog. Ser.* 375:247-261. |
| SC/17/WWG/O08 | 9 | Udevitz, M.S., Jay, C.V., Fischbach, A.S. and Garlich-Miller, J. (2009) Modeling haul-out behaviour of walruses in Bering Sea ice. *Can. J. Zool.* 87:1111-1128. |
| SC/17/WWG/O09 | 5 | Stewart R.E.A. (2008). Redefining walrus stocks in Canada. *Arctic* 61(3):292-308. |
| SC/17/WWG/O10 | 5.1 | Andersen, L.W., Born, E.W., Doidge, D.W., Gjertz, I., Wiig, Ø. and Waples, R. S. Genetic signals of historic and recent migration between sub-populations of Atlantic walrus (*Odobenus rosmarus rosmarus*) west and east of Greenland. |
| SC/17/WWG/O11 | 5.1 | Lindqvist, C., Bachmann, L., Andersen, L.W., Born, E.W., Arnason, U., Kovacs, K.M., Lydersen, C., Abramov, A.V. and Wiig, Ø. (2009). The Laptev Sea walrus *Odobenus rosmarus laptevi*: an enigma revisited. *Zoolgica Scripta* 38(2):113-127. |

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|---|---|---|
| SC/17/WWG/O12 | 6.1, 9.1 | Skoglund, E.G., Lydersen, C., Grahl-Nielsen, O., Haug, T. and Kovacs, K. M. (2009). Fatty acid composition of the blubber and dermis of adult male Atlantic walruses (*Odobenus rosmarus rosmarus*) in Svalbard, and their potential prey. *Mar. Biol. Res*. In press. |
| SC/17/WWG/O13 | 12 | Boertmann, D., Mosbech, A., Schiedek, D. and Johansen, K. (eds) 2009. *The western Greenland Sea. A preliminary strategic environmental impact assessment of hydrocarbon activities in the KANUMAS East area.* National Environmental Research Institute, Aarhus University, Denmark. 246 pp. http://www2.dmu.dk/Pub/FR719.pdf (not on file exchange site – too large). |
| SC/17/WWG/O14 | 12 | Boertmann, D., Mosbech, A., Schiedek, D. and Johansen, K. (eds) 2009. *The eastern Baffin Bay. A preliminary strategic environmental impact assessment of hydrocarbon activities in the KANUMAS West area.* National Environmental Research Institute, Aarhus University, Denmark. 238 pp. http://www2.dmu.dk/Pub/FR720.pdf (not on file exchange site – too large). |
| SC/17/WWG/O15 | 12 | Boertmann, D., Olsen, K. and Nielsen, R.D. 2009. *Seabirds and marine mammals in Northeast Greenland. Aerial surveys in spring and summer 2008*. National Environmental Research Institute, Aarhus University, Denmark. 50 pp. http://www2.dmu.dk/Pub/FR721.pdf (not on file exchange site – too large). |
| SC/17/WWG/O16 | 12 | Mosbech, A., Boertmann, D. & Jespersen, M., 2007. Strategic Environmental Impact Assessment of hydrocarbon activities in the Disko West Area. - NERI Technical Report 618. http://www2.dmu.dk/Pub/FR618_0_kap_3.pdf (not on file exchange site – too large). |
| SC/17/WWG/O17 | 12 | Gautier, L. D. *et al.* 2009. *Assessment of undiscovered oil and gas in the Arctic*. Science 324:1175-1179. DOI: 10.1126/science.1169467. |
| SC/17/WWG/O18 | 8.1 | Born, E.W. and Knutsen, L. Ø. 1997. Haul-out activity of male Atlantic walruses (*Odobenus rosmarus rosmarus*) in northeastern Greenland. Journal of Zoology (London) 243:381-396. |
| SC/17/WWG/O19 | 8.1 | Fay, F.H., L.L. Eberhardt, B.P. Kelly, J.J. Burns and Quakenbush, L.T. 1997. Status of the Pacific walrus population, 1950-1989. Marine Mammal Science 13: 537-565. |

ANNEX 3

**REPORT OF THE
NAMMCO SCIENTIFIC COMMITTEE
WORKING GROUP ON
MARINE MAMMALS AND FISHERIES INTERACTIONS (MMFI)**

13-14 March 2010, Copenhagen, Denmark

## 1. OPENING REMARKS

Working Group (WG) chair Lars Walløe welcomed the convened delegates (Section 5.9), expressed the WG's regrets that Garry Stenson could attend this meeting and also thanked him for sending his written contribution. Walløe proceeded with a brief review of the last meeting of this WG held in Reykjavik in 15-17 April 2009 (NAMMCO 2009) and especially reminded the delegates that the present meeting was held according to point one of the proposed work plan: "A meeting to compile detailed proposals and budgets".

## 2. ADOPTION OF AGENDA

The agenda was adopted (Appendix 1).

## 3. APPOINTMENT OF RAPPORTEURS

Acquarone, Scientific Secretary of NAMMCO, was appointed as rapporteur for the meeting, with the help of members as needed.

## 4. REVIEW OF AVAILABLE DOCUMENTS

Documents available to the meeting are listed in Appendix 2.

## 5. DATA

The WG agreed that the complexity of the exercise, and for the sake of consistency, some Data Officers need to be appointed for each of the two modelling areas (Barents' Sea and Icelandic waters). In a first time, the role of these Data Officers would be to compile a summary table of all the ecosystem data available including any associated metadata and possible information about data rights and restrictions in usage. Walløe and Hjermann volunteered to identify suitable candidates for Barents' Sea data and similarly Víkingsson and Stefansson agreed to proceed for data from Icelandic waters.

**Barents' sea (including extension on the East and South, to the Lofoten)**
Hjermann gave a quick overview of the abundance and distribution data available for the Barents Sea area. In general, there seems to be adequate coverage for ground fish, February cod (since 1981), October capelin (since 1972, though there are deficiencies in intermediate periods), herring (only for ages 1 and 2). He also noted that data on sandeel are lacking. He then pointed out that the Norwegian institutions traditionally

gather zoo- and phytoplankton data from the autumn (Aug-Sept). Data from this period might not be adequate for the purpose of this WG as at that time the quantity of plankton in the autumn is likely reduced after predation by fish but that Russian data from other periods might be available. As far as marine mammals are concerned there are good data on whales, though they present a high degree of mobility among the different areas in Norwegian waters. Conversely, available data on abundance, movement and diet for harp seals are probably not adequate. Other ecosystem data may be available at the Marine Research Institute in Bergen (persons to contact there were identified as Hein Rune Skjoldal and Ken Drinkwater).

**Icelandic waters**

Stefansson reported that Icelandic institutes regularly conduct main surveys for zoo and phytoplankton (though shortened through the years), 0-group surveys, surveys for fish (especially cod and capelin) and shrimps. Biological data is regularly obtained from the catches. As far as capelin is concerned, due partially to problems with acoustic surveys, data are available but have not been consistently entered into a database. There is a disconcerting lack of data on sandeel, which in the past represented a large component of the diet of marine mammals. Good data are available for minke, fin and humpback whales as well as for harbour and grey seals. Abundance estimates for cetaceans originate from regular surveys conducted regularly since 1987. Recent data suggests a shift in minke whale distribution and diet (from 3 to 15% cod but much less abundance of whales). Whaling operations to date have provided data on fin whales, while information on humpback whales is limited to prey association. Regarding harbour and grey seals some abundance and diet data is available, but data from harp and hooded seals are lacking. Birds seem not to have a big influence in biomass extraction from either area (~1%).

## 6. AREAS

Morissette pointed out that criteria for selection of a study area/ecosystem to be modelled should include data availability, relative simplicity of the food-web, strong species interactions, relatively closed system boundaries and low environmental forcing (IWC 2004). Based on these considerations and on the fact that consumption estimates, biomass, catches and mortality for key fish (capelin, herring, cod) and marine mammal species (minke whales) are all available for the Barents' Sea, this ecosystem is ideal for the intended modelling exercise. It might be necessary to consider further subdivisions of the area to simplify analyses. However, 7 sub-areas (as used in Tore Schweder's 'Scenario Barents Sea Study' (SBS) model) may be a too much (many unknown migration parameters). Likewise Stefansson suggested that some subdivisions of the Iceland area might be necessary, but underlined that cod-biologists should be consulted before any decision is taken in this direction.

## 7. MODELLING APPROACHES IN GENERAL

The WG agreed that the primary objective of this exercise is to investigate if a variety of models presents robustness regarding the qualitative direction of the impact on major commercial fish species of reducing marine mammal numbers. In order to facilitate the task of writing funding applications it was suggested that:

- Notations should be coordinated to reduce confusion.
- A 2-pages project description should be provided as soon as feasible for each of the four modelling approaches.
- A more in-depth project description should also be provided for internal use, on the lines of the one already provided by Morissette (SC/17/MMFI/04).
- Walløe and Butterworth should provide a short description of the coordination component.
- All approaches should each provide a budget. It was estimated that 600-900,000 NOK/year*model for in total 12,000,000 NOK will be needed. Budgets should include:
    - Salary for meeting preparation and attendance
    - Costs of all hardware and software needed.
- The coordination work-package should also provide a budget.
- The two Data Officers (see §5) should as soon as feasible provide a document describing the data.
- Possibilities and problems with data sharing should be identified, especially for data that has not yet been published in relation to publishing and authorship.
- Allowance should be made for 2-3 face-to-face meetings per year for discussion of scientific issues dealing with coordination in addition to intersessional webinars.
- Already at the project description phase, functional responses for comparison across the models should be identified and controlled and effort should be made towards using the same type in all models. The following considerations were made:
    - Type 1 and 2 only? Type 2 and 3 only? Arena model?
    - Should some of the parameters be fixed?
    - Within the range the following three types should be covered:
        - Holling type 2.
        - Holling type 3.
        - Foraging arena model.
    - Individual modellers could extend these.
    - At a later stage in the project, efforts should be made to render these as similar as possible between models for more comparable results.
- A set of research questions that is common for all approaches must be defined - the models should seek to answer the same questions. Examples: what is the effect of removing a certain percentage of a mammal species each year; or lowering the abundance a certain percentage. It must also be defined whether the "extra" fish is fished (using some simple harvest control rule), or just left in the ocean.
- The models should not give priority to modelling effects of climate variation and trends
- Uncertainty:

- The model approaches should handle uncertainty as similar as possible. If one model has a broader uncertainty just because the researcher has been better at including different sources, one can falsely get the impression that this model is "worse" than the others.
- Rather than the Bayesian approach of including the box of all uncertainties, pick a few (3-ish) major uncertainties (i.e., parameters with uncertain values) and run the models with different values for these parameters.

### 7.1. Minimal realistic model implemented using GADGET

Stefansson listed the following considerations:

- The modelling will be focussing on relationships between minke whales and cod.
- For the Icelandic waters a candidate for the modelling exercise is Bjarki Elvarsson.
- To identify a candidate for the Barents' Sea Stefansson will contact Daniel Howell.
- Simpler harvest control rules for fish and shrimp need to be established. The existing ones are complex and may be difficult to implement. It was suggested to design new ad hoc harvest rules that mimic the actual implemented harvest strategies (but depending on the inclusion or not of stochastic components).
- Investigate the existence of feeding functional relationships, however the parameters needed are not in place.

### 7.2. *Ecopath* with *Ecosim* (*E*w*E*)

Morissette pointed out that:

- It is necessary to define clearly which "measures" or "questions" to compare across the tools.
- The goal to the modellers is to attempt at providing some management advice. (i.e. "for each whale taken annually so many extra tons of cod could also be taken").
- *EwE* includes tools to address uncertainties and that it would be productive to implement similar tools for the other modelling approaches in view of a comparison across the approaches.
- It is essential to define clearly the input parameters (SC/17/MMFI/04).
- The modelling approach using *EwE* requires an experienced user, which precludes designing the project for researcher education (i.e. PhD study).

### 7.3. Time series regression

Hjermann listed the following considerations regarding the application of the time series regression modelling approach:

- Care should be taken when considering functional responses which are age specific (linear or non linear). In this respect the main challenge regarding marine mammals is that there are no age specific data.
- A suitable student candidate who has made a state-space-based model for cod on the same line as the one in this project has been identified.

**7.4. Bioenergetic-allometric Modelling of the Barents and Icelandic Sea Ecosystems**

Butterworth presented the document SC/17/MMFI/05 provided by Stenson. From the description also this approach is "minimal realistic", however the essence of the difference from the one implemented using GADGET (Item 7.1) is that the former considers only the biomass and does not includes age structure. The WG noted that the species to be included should be added to the project description. In general this approach investigates different feeding interactions in details. The following comments were made:

- It would be useful to define which species will be included and if there are any plans of differentiating between juveniles and adults.
- If possible the model should be run with and without the temperature parameter.
- If possible the model should investigate additional functional relationships.

## 8. COORDINATION

Walløe and Butterworth were unanimously tasked to take charge of the overall coordination component of the project. The role of the coordinators was defined as follows:

- Ensure that the answers from the models are comparable.
- Moderate the run of the models to be as simple as possible in the first place and then eventually employ more complex refinements.
- Adjust the dynamic schedule for the meetings, deliverables and deadlines.
- Liaise with the Data Officers.

## 9. RECOMMENDATIONS FOR PROGRESS

The WG **concluded** that there is sufficient basis for proceeding with the planned modelling exercise for both areas and that funding applications should include both the Barents' Sea and Icelandic water areas. In particular the WG noted that obtaining adequate input data for the Ecopath with Ecosim (EwE) approach may be more challenging than for the other approaches as EwE necessarily includes lower trophic levels. However, it was recognized that Ecopath analyses have previously been done for both areas and these could act as useful starting points in the interest of facilitating the task. The effort necessary for the EwE component was estimated at 1.5 man/years distributed over 3 years. The WG also **agreed** that funding should be sought from the following sources and in this order of priority:

1. Nordic Council Ministers
2. European Union
3. Norwegian sources.

## 10. ADOPTION OF REPORT

This report was approved in a preliminary form at the end of the meeting and it was finally adopted by correspondence on 19 April 2010.

Appendix 1

## AGENDA

1. OPENING REMARKS
2. ADOPTION OF AGENDA
3. APPOINTMENT OF RAPPORTEURS
4. REVIEW OF AVAILABLE DOCUMENTS
5. DATA
6. AREAS
7. MODELLING APPROACHES IN GENERAL
    7.1. Minimal realistic model implemented using GADGET
    7.2. *Ecopath* with *Ecosim*
    7.3. Time series regression
    7.4. Bioenergetic-allometric Modelling of the Barents and Icelandic Sea Ecosystems
8. COORDINATION
9. RECOMMENDATIONS FOR PROGRESS
10. ADOPTION OF REPORT.

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**Instructions to the MMFI WG from the report of the NAMMCO Scientific Committee 16th Meeting:**

The SC **recommends** that [a] coordinated project be initiated as soon as possible and agrees on the broad lines developed by the WG for such exercise. The first phase of the work would involve fitting different models to the available data and comparing their projection results. Ideally, in a second stage, the models could each be subjected to common simulation testing for an indication of which might be providing the more reliable results.

This exercise should include at least 4 different modelling approaches. The best candidates, together with potential group leaders, were identified as:
• Minimal realistic model implemented using GADGET (Stefansson)
• *Ecopath* with *Ecosim* (Morissette)
• Time series regression (Hjermann)
• A simple biomass-based model such as one recently applied in eastern Canada.

The structure of the models should allow for the possibility of multiple stable equilibria in the absence of exploitation.

The exercise should be carried out preferably for two areas. Likely candidates include the Barents Sea and the region around Iceland. If resources are insufficient, one of these should be chosen, and the advantages and disadvantages of each should be developed for consideration. Once funding is obtained, selection of appropriate area(s) should, if necessary, be decided by a working group of experts knowledgeable in the data requirements and availability.

The tentative schedule provided for the work was articulated around 4 key-step meetings with a 2-year period as a realistic time-span for the whole process:
1. A meeting to compile detailed proposals and budgets; leaders of the different modelling teams would be essential participants; meeting to be held as soon as feasible.
2. A data oriented meeting – common data would need to be carefully pre-agreed to ensure that the results from the different models were comparable.
3. A meeting of the modelling groups to critically compare and suggest improvements to their first attempts in fitting their models to the data.
4. A meeting at which final model results are tabled for consolidation, and draft consequent management-related recommendations are developed.

It might be possible to combine meetings 1. and 2. above into one. Such a multi-modelling effort can only be carried out through a coordinated modelling programme.

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**Terms of Reference (ToR):**

**NAMMCO/12 – (03-2003):**
The Management Committee agreed that the Scientific Committee should monitor progress made in multispecies modelling and in the collection of input data and decide when enough progress has been made to warrant further efforts in this area. Future meetings should focus on assessing modelling results from the Scenario Barents Sea model and possibly the GADGET-based template models for other areas, if they are developed. The Scientific Committee should also consider the feasibility of connecting the multi-species models with simple economic models at that time.

**NAMMCO/16 – (02-2007):**
The Commission requested the Scientific Committee to review the results of the Icelandic programme on the feeding ecology of minke whales and multi-species modelling as soon as these become available.

**NAMMCO/17 – (09-2008):**
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.

Appendix 2

**LIST OF DOCUMENTS**

| **Document no** | **Agenda item** | **Title** |
|---|---|---|
| SC/17/MMFI/00 | | Practical arrangements. |
| SC/17/MMFI/01 | | List of Participants. |
| SC/17/MMFI/02 | | Draft Agenda. |
| SC/17/MMFI/03 | | List of Documents. |
| SC/17/MMFI/04 | 6 | Morissette "Assessing marine mammal-fisheries interactions using Ecopath with Ecosim". |
| SC/17/MMFI/05 | 8 | Stenson *et al.* "Bioenergetic-allometric Modelling of the Barents and Icelandic Sea Ecosystems". |
| SC/17/MMFI/O01 | | AGFisk Funding Application "Network on Marine Ecosystem modelling to improve ecosystem based management". |
| SC/17/MMFI/O02 | | "Barecore - Barents Sea ecosystem resilience under global environmental change". |

ANNEX 4

**REPORT OF THE**
**NAMMCO SCIENTIFIC COMMITTEE WORKING GROUP (WG) ON ASSESSMENT (AS)**

9 - 11 March 2010, Copenhagen, Denmark

## 1. OPENING REMARKS

Chair Lars Walløe welcomed the Delegates (Section 5.10) and conveyed the apologies of Scientific Secretary Mario Acquarone whose flight was delayed due to adverse weather conditions on departure. Walløe reminded the Delegates of the Terms of Reference of this working group (WG) previously circulated as notes to the Agenda (Appendix 1).

## 2. ADOPTION OF AGENDA

The Agenda (Appendix 1) was adopted in a slightly modified form.

## 3. APPOINTMENT OF RAPPORTEURS

Acquarone was appointed rapporteur *in absentia*. Pike and Øien took notes in his absence during the first day of the meeting.

## 4. REVIEW OF AVAILABLE DOCUMENTS AND REPORTS

The available documents are listed in Appendix 2.

## 5. THE CENTRAL NORTH ATLANTIC MINKE WHALE STOCK

### 5.1 Stock structure

Past views expressed by both the Scientific Committee of NAMMCO (NAMMCO SC) and the Scientific Committee of the International Whaling Commission (IWC SC) indicate agreement, on the basis of available data and analysis, that there is only one stock for minke whales in the Central North Atlantic. In line with this, the WG decided to continue to assume the one-stock hypothesis for the area.

Recent work by Skaug refutes supposed differences between the central and eastern management areas (SC/17/AS/O18, Pampoulie *et al.* 2008, Skaug 2008) – see Fig. 1. However, this question was not addressed further during this meeting in the interest of time.

### 5.2 Biological parameters

No new information was presented.

### 5.3 Catch data

The catch series for minke whales for the central area is reproduced in Appendix 3. The sex ratio in the Icelandic catch since resumption of commercial whaling in 2006 is 81% males (n=107).

**5.4 Abundance estimates**

In document SC/17/AS/07 Pike presented the Icelandic aerial survey carried out in summer 2009 which represents the continuation of a series of surveys, using nearly identical design and methodology, conducted in 1987, 1995, 2001 and most recently in 2007 (Pike *et al.* 2008, 2009a). The 2009 survey was carried out primarily because the abundance of minke whales estimated from the 2007 survey was not consistent with earlier surveys. Pike *et al.* (2008) estimated that the abundance of minke whales in 2007 was just 24% of that estimated for 2001 by Borchers *et al.* (2009). Results from a partial survey carried out in 2008 suggested that the 2007 results might be anomalous (Gunnlaugsson *et al.* 2009). A total of 169 non-duplicate sightings of minke whales were made by the primary and secondary observers. Data analyses were carried out using the DISTANCE 5.0 (Thomas *et al.* 2009) soft-ware package and stratified cue-counting methods (Hiby and Hammond 1989, Hiby *et al.* 1989, Buckland *et al.* 2001). Effective detection radius (*edr*) was twice as high as that estimated for the 2007 survey and considerably higher than in previous surveys, which means that the observers were distributing their searching effort over a larger area in 2009. The total estimate for the original blocks is 5,900 (95% CI, 3,423 to 8,803). Post-stratification to remove portions of strata that were not covered decreases this estimate by 9%. This estimate is not corrected for bias due to visible cues being missed by observers (perception bias). The available evidence indicates that both primary observers did miss cues within 200 m of the plane, suggesting that correction for this bias would result in a somewhat higher abundance estimate. Bias due to error in distance estimation is apparently not significant. Accepted abundance estimates are available from 1987, 2001, 2007. Abundance decreased substantially between 2001 and 2007 in nearly every stratum and in the total survey area. In spite of the higher encounter rate in 2009 than 2007 and similar to some past surveys the uncorrected estimate of total abundance in 2009 was the lowest yet recorded: just 14% of that estimated in 2001 and 55% of that recorded in 2007. Future correction for availability bias will increase the estimate but the increase will probably not make the estimate consistent with previous high estimates (pre-2007). Possible reasons for this decrease include changes in spatial/temporal distributions as the most likely explanation. While a population decrease cannot be completely excluded, it cannot have been caused by the low level of catch in the area (a total of 326 in the past 7 years).

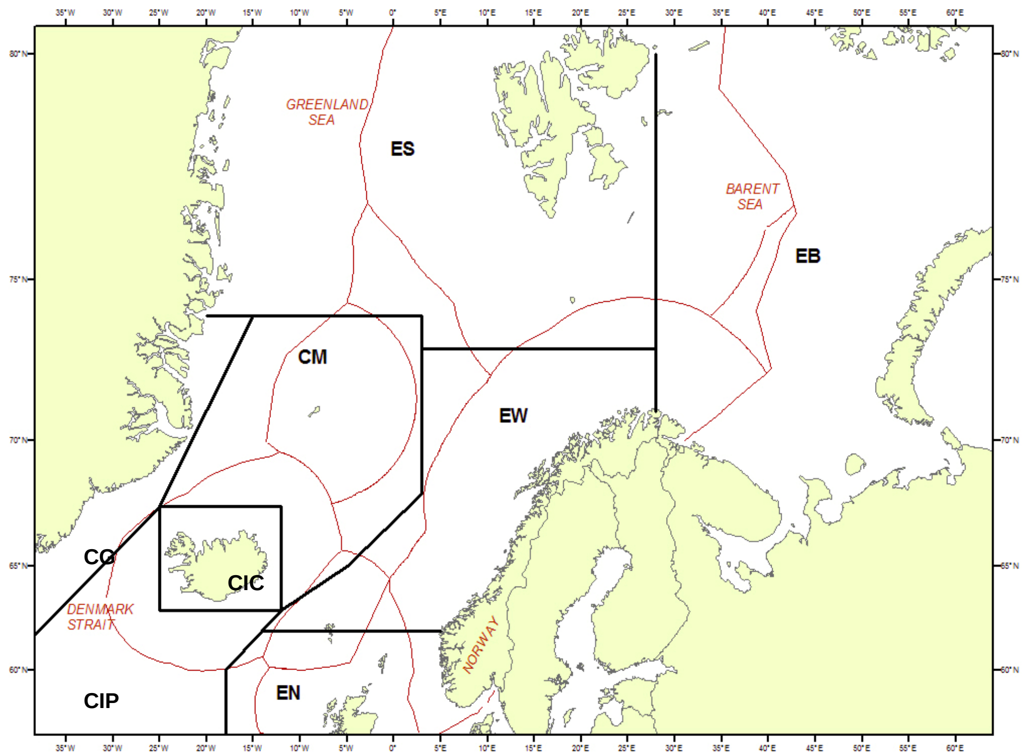


**Fig. 1**. Management subareas for "mixed coastal and pelagic" whaling trials (courtesy of IWC).

Pike continued by presenting the document SC/17/AS/05. Previous abundance estimates for minke whales from the Icelandic and Faroese NASS ship surveys have been summarized by Pike *et al.* (2009b). These estimates were not corrected for perception bias (visible whales that are missed by observers) or for availability bias (whales that are missed because they are diving while the vessel passes). SC/17/AS/05 provides a compatible estimate from the T-NASS survey conducted in 2007. Abundance was estimated both with and without the effort and sightings of these vessels within the primary survey area. The basic field methodology followed to the Buckland and Turnock (BT) mode (Buckland and Turnock 1992). On all vessels, observers on the primary platform operated independently of the tracker platform, but made all sightings known to the duplicate identifier on the tracker platform. The duplicate identifier entered sightings data on special computer/digitalised forms. In addition to the 3 primary survey vessels, 3 other vessels conducting fishery research in the area were utilized as platforms of opportunity during the survey. These vessels were each staffed with 2 whale observers on a single platform who made and recorded sightings using methods identical to those used on the primary platforms of the dedicated survey vessels. A total of 32 sightings of high to medium certainty minke whales were sighted by the dedicated vessels, and an additional 9 were sighted by the extension vessels. Abundance was estimated using conventional distance sampling methods with no corrections for perception or availability biases or possible responsive movement. Abundance was estimated to 10,782 (95% CI, 4,733 to 19,262) for entire survey area covered by the dedicated vessels. Adding effort and sightings from the extension vessels reduced this estimate by 32%, probably because of a lower *g*(0) on these vessels. Post-stratification to account for areas that were covered by pack ice at the time of the survey reduced the estimate by 5%. The authors pointed out that this estimate should be considered negatively biased by uncorrected perception and availability biases, and possibly also by movement of whales in response to the vessels. Unfortunately, the double platform data collected are insufficient to correct for these biases. Furthermore, the survey vessels were unable to cover the area off East Greenland, an area that had high densities of minke whales in previous surveys, because of unfavourable weather and ice conditions. In addition, coverage was poor in the northern areas, and within this area minke whale densities were highest near the northern boundary of the surveyed area. This should therefore be considered a minimum estimate for the survey area, and probably more downward biased than some previous surveys.

In discussion, it was noted that one possible explanation for the northern distribution may be that the herring stock summering in the Norwegian Sea now has reached its maximum level and distributional extension, and may compete with minke and fin whales for zooplankton. This makes it necessary for these whales to search for high-density plankton patches outside the grazing areas of herring.

Some details of the analysis were also discussed. It was pointed out that the fitting of detection functions to perpendicular distances, involve a very prominent tail. This could be the reason why half-normal probability functions with additional terms gave the best fits to the data as they have the capacity to reflect this feature, but at the expense of a poorer fit close to the track line. On inspection of the distributions, it was suggested that data should be truncated at 600 m, for better fits close to the track line. Pike advised that he had conducted such analyses, which led to an increase of 16% in the abundance estimate but with a concomitant loss of precision.

Øien informed the WG that the Norwegian surveys had covered in 1997 and in 2005 the Small Area CM, which contains the N block in the Icelandic survey (Fig. 2), but extends further north to 74°N. The estimates of minke whale numbers within the CM Small Area were about 27,000 animals in both surveys, thus there are indications of a stable situation with regard to minke whales in that area in the 10-year period prior to the Icelandic 2007 survey.

Minke whale abundance estimates for CM area (complete) from Norwegian surveys are reported here in the table below:

| Survey | Year | N | cv | Comments |
|---|---|---|---|---|
| NASS-87 | 1987 | 5,609 | 0.26 | Uncorrected and incomplete area coverage |
| NASS-95 | 1995 | 12,043 | 0.28 | NM: *g*(0) corrected with Norwegian Method, except NVS part from Icelandic survey |
| NILS-1996-2001 | 1997 | 26,781 | 0.14 | NM: *g*(0) corrected with Norwegian Method |
| NILS-2002-2007 | 2005 | 26,739 | 0.39 | NM: *g*(0) corrected with Norwegian Method |

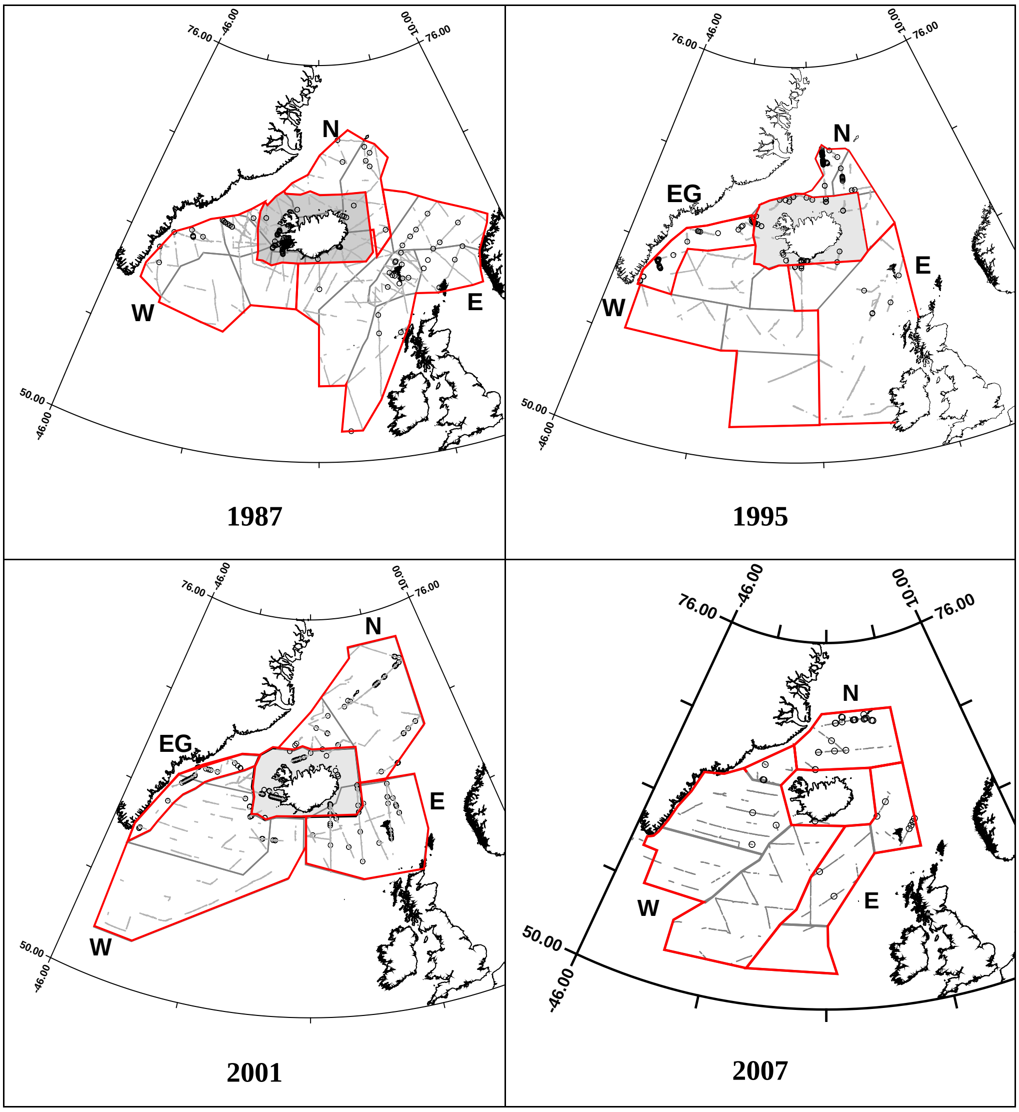


**Fig. 2.** Sightings of minke whales in NASS, 1987 to 2007, with 1989 excluded. The 4 regions N, E, W and CG (used in Table 1) are outlined in red.

Table 1 summarizes estimates from Icelandic shipboard and aerial surveys, and Norwegian ship surveys in the CM Small Area. The Icelandic shipboard estimates are divided into three regions roughly corresponding to the eastern, western and northern parts of the survey areas (Fig.2). In addition, the coastal area of East Greenland (CG), which was well covered only in 1995 and 2001, is extracted as a separate area in those years to make the regional estimates more compatible. Density in the Western region (excluding CG) was estimated to be lower than the overall density for all surveys, and particularly low in 1995 (0) and in 2007. No trend is apparent for this region. Density near East Greenland was relatively high in years in which this area was well covered (1995 and 2001). Density in the Eastern region was roughly average for the overall survey area, but was higher in 2001 and 2007 than in earlier surveys, suggesting a positive temporal trend. However, this may be a reflection of the smaller areas covered in this region in the latter two surveys (2001 and 2007). The Northern region has the highest minke whale densities in the ship survey area outside of CG. Most sightings in this region have been made near Jan Mayen. There appears to be no trend in density in the region. Overall numbers and density (excluding CG) were highest in 2001 but the higher estimate is partially due to the larger coverage in that year, particularly in the high density Northern region. No overall trend is discernable. Density in the aerial survey area exhibited a non-significant increase between 1987 and 2001, and the higher estimate in 2001 is partially due to the greater coverage in that year. There was a sharp drop in the 2007 estimate and this trend has continued with the 2009 estimate. Overall, the fluctuations in numbers and density in the ship survey can largely be attributed to changes in the size of the survey area as a whole combined with coverage or lack of coverage of the CG area. Changes in total numbers for all areas combined are largely attributable to the recent decline in the aerial survey estimates.

| | | 1987 | 1995 | 2001 | 2007 | 2009 * |
|---|---|---|---|---|---|---|
| W | ***D*** | 0.0172 | 0 | 0.014 | 0.0033 | |
| | ***N*** | 3,097 | 0 | 4,705 | 1,506 | |
| | ***CV*** | 0.31 | 0 | 0.62 | 0.56 | |
| | ***%TOT*** | 25 | 0 | 25 | 14 | |
| | ***%DEN*** | 82 | 0 | 48 | 23 | |
| E | ***D*** | 0.0141 | 0.0113 | 0.0346 | 0.0241 | |
| | ***N*** | 4,418 | 2,736 | 4,394 | 3,412 | |
| | ***CV*** | 0.24 | 0.46 | 0.41 | 0.38 | |
| | ***%TOT*** | 36 | 21 | 17 | 32 | |
| | ***%DEN*** | 67 | 75 | 119 | 167 | |
| N | ***D*** | 0.0548 | 0.1141 | 0.0533 | 0.061 | |
| | ***N*** | 4,167 | 5,495 | 9,473 | 5,847 | |
| | ***CV*** | 0.244 | 0.271 | 0.276 | 0.5 | |
| | ***%TOT*** | 34 | 67 | 51 | 54 | |
| | ***%DEN*** | 261 | 761 | 184 | 424 | |
| TOTAL[1] | ***D*** | 0.021 | 0.015 | 0.029 | 0.0144 | |
| | ***N*** | 12,179 | 8,231 | 18,571 | 10,782 | |
| | ***CV*** | 0.16 | 0.27 | 0.27 | 0.36 | |
| AERIAL | ***D*** | 0.3747 | | 0.5101 | 0.1249 | 0.069 |
| | ***N*** | 24,532 | | 43,633 | 10,680** | 5,900 |
| | ***CV*** | 0.32 | | 0.19 | 0.27 | 0.23 |
| TOTAL[2] | ***D*** | 0.0558 | | 0.0863 | 0.0263 | |
| | ***N*** | 36,711 | | 62,204 | 21,462 | |
| | ***CV*** | 0.22 | | 0.16 | 0.23 | |
| CG | ***D*** | | 0.1084 | 0.205 | | |
| | ***N*** | | 5,972 | 7,990 | | |
| | ***CV*** | | 0.26 | 0.38 | | |
| TOTAL[3] | ***D*** | | | 0.0924 | | |
| | ***N*** | | | 70,194 | | |
| | ***CV*** | | | 0.14 | | |

**Table 1.** Comparison of density (*D*) and abundance (*N*) of minke whales from NASS ship surveys by region. ***%TOT*** – percentage of total abundance; ***%DEN*** – percentage of density over entire area. **TOTAL[1]** – Total outside aerial blocks, not including CG; **TOTAL[2] –** Total including aerial blocks, not including CG; **TOTAL[3]** – Total including all surveyed areas. * this abundance estimate has not yet been formally accepted by NAMMCO. ** An alternative estimate and equally acceptable earlier estimates is 15,055 (CV=0.36).

Víkingsson introduced document SC/17/AS/06 which provides a preliminary analysis of minke whale stomach contents data collected in Icelandic waters showing considerable changes in diet composition during 2003-2007. Thus, the proportion of sandeel decreased over the sampling period while herring and gadoids (cod and haddock) increased. The results also differed appreciably from the limited previously available data from Icelandic waters (1980-1995), notably with less capelin and krill and more gadoids and herring in the more recent period. The observed changes in diet composition of minke whales during the study period, together with recent increase in sea temperatures and associated changes in the marine environment may help explain recent decline in abundance of minke whales in the area. After the turn of the century, large changes have occurred in the Icelandic continental shelf ecosystem. Most of these changes appear to be unfavourable to minke whales, notably less abundance of important prey species such as sandeel, capelin and krill. The summer distribution of capelin has shifted from northern Icelandic waters to the east coast of Greenland, into an area that was very poorly surveyed in the 2007 survey. Although there is evidence of minke whales in coastal waters having reacted to this to some extent by switching to other prey species, such as cod, haddock and herring, minke whale abundance has also decreased significantly during this period. Detailed examinations of body condition of 200 minke whales sampled during 2003-2007 have not revealed any instances of severe malnutrition. Such instances would be expected if the decline in abundance was due to a real population decline, as a result of food shortage. Thus, it seems more likely that the decline is the result of a shift in distribution from Icelandic coastal waters.

In the discussion that followed on whether the observed changes in diet were linked to the changes in abundance and distribution of minke whales, it was suggested that the basic mechanism could be a temperature shift in the area, which in turn had led to a change in the distribution of capelin. After 2005, capelin had to a large extent disappeared from the shelf areas north of Iceland, and this coincides with the decreased abundance of minke whales in these areas. There had been a drop from about 30% to about 10% of capelin in the composition of minke whale diet from 1985 to 2007. One hypothesis could then be that the minke whales had followed a change in distribution of the capelin, as reflected by the high density of minke whales, which seems to begin at the western and northern boundary of the “IN” (also called N in Fig. 2) northernmost block in the 2007 shipboard survey.

The WG suggested that the relationship between cetacean distribution and temperature changes in the area should be investigated (see recommended research). The WG noted that information about spatial and temporal changes in distribution of capelin in the North Atlantic is available (SC/17/AS/06, SC/17/AS/O19, SC/17/AS/O20). This information should be taken into account in this investigation.

A question was raised regarding the length distribution of the sampled minke whales as there could be a link between maturity status and food preference and that the length distributions might have changed over the years of sampling. However, checks showed that the mean lengths in the samples had been stable throughout the sampling period and were about 750-800 cm, which would indicate sexually mature animals.

**In Summary**

Table 2 lists estimates of minke whales from Icelandic aerial and shipboard surveys of the Central North Atlantic. Comprehensive coverage took place in 3 years: 1987, 2001 and 2007, with abundance estimates totalling 37, 62 and 21 thousand whales respectively. An important question that arises is whether the low final figure reflects an appreciable reduction in population abundance on the known feeding grounds (and if so, why has this occurred?). The WG agreed that this drop from 2001 to 2007 is primarily a consequence of a much reduced estimate from aerial surveys of the Icelandic coastal region, representing only a small proportion of the distribution area of the Central North Atlantic stock.

These results must, however, be considered in the context of the marine environment in Denmark Strait and the Greenland Sea which has undergone some dramatic changes over recent years, including record low sea ice distribution and increasing sea temperatures. It is expected, and to some extent observed, that these changes have cascaded through the ecosystems in these areas with profound effects on distributions and abundance of fish species and especially of bentho-pelagic schooling species like capelin. Capelin in particular has been identified as a species that is sensitive to changes in sea temperature (SC/17/AS/O21), and the distribution of the spawning stocks is usually limited by 2-4$^{o}$C, with the use of warmer water unlikely during the summer feeding season. With increasing temperatures around Iceland it is likely that capelin have chosen more northern areas for feeding, and consequently are no longer as abundant on the Icelandic shelf areas as they used to be except during the spawning migration in January/early March. The spawning takes place in much warmer water (8-9°C, south and west of Iceland), but there are no indications that the spawning areas has changed despite the warming. The stock has however been smaller during the last decade, compared with the period since 1977 (when the acoustic measurement started) and could be related to reduced area with favourable conditions for juvenile and feeding adults north of Iceland and in the Denmark Strait.

In all areas, capelin has been identified as a key prey item for minke whales, and a plausible hypothesis is that at least some of minke whales in the Central North Atlantic would follow the capelin to areas that are more northern. This, together with a dramatic decrease in sandeel abundance, might explain some or all of the apparent changes in distribution and abundance of minke whales both on the Icelandic shelf area (the Icelandic aerial surveys) and the offshore areas (the Icelandic ship surveys). A situation where most of the minke whale detections during the 2007 Icelandic shipboard survey were made on the northernmost transect-line in the northernmost strata indicates that the core area of the distribution was not covered by the survey, and more minke whales could be expected to be found north of the survey boundary. Curiously, the Norwegian surveys in the same area do not show such a change.

Overall the fluctuations in numbers and density in the Icelandic/Faroese ship survey can largely be attributed to 1) changes in the size of the survey area as a whole, especially the size of the high-density northern area, and 2) lack of coverage in the area near East Greenland in some years. Estimates from Norwegian surveys conducted in CM in 1997 and 2005 are very similar, but unfortunately no Norwegian surveys have been conducted in the area after the first detection of decreased abundance in CIC in

2007. The large decline in the estimates for the Central Area as a whole between 2001 and 2007 can therefore largely be attributed to the decline in the aerial survey estimate in 2007 and 2009.

In the absence of any obvious indications of an increase in minke whale natural mortality around Iceland, it is unlikely that the trend in abundance (Table 2) reflects a real decline in population size. None of the surveys covered the entire distribution of the population and apparently, a substantial number of minke whales moved out of the survey area between 2001 and 2007. At present, the mechanism behind these re-allocations of minke whales is not fully understood. However, it seems plausible that the large-scale ecological changes in the North Atlantic are driving the changes in distribution of minke whales. One example of this is the increasing numbers of male minke whales in the southern area of West Greenland since 2002 that is apparently related to the simultaneous increase in temperature in Southwest Greenland (SC/17/AS/O16). One explanation of this change in sex ratio could be an influx of minke whales from South and Southwest Iceland where the proportion of males has been around 80% males according to catches in recent years.

**5.5 Assessments**

Assessments of the Central North Atlantic minke whale population have been presented in previous reports (NAMMCO 2000, 2005 and 2010). They uniformly show a resource reduced only slightly below its pre-exploitation level, because cumulative past takes have been small relative to estimates from surveys of the recent abundance of the population. There was insufficient time to rerun these analyses for this meeting to take account of the most recent survey data. (Appendix 4 shows IWC runs for minke whales executed previous to this meeting.) However, these further data are not such as would result in a qualitative change to the earlier results mentioned above.

**5.6 Management Advice**

The Council had requested advice on the long-term sustainability of catches of common minke whales in the Central North Atlantic once results from the 2009 survey became available. The WG considered that implementation of the IWC RMP (IWC 1994) to calculate catch limits provided an appropriate basis to address the Council's request.

The RMP can be applied at a "*Small area*" level, or to combinations of such "*Small areas*". For the Central North Atlantic minke whale population, 4 such areas are concerned: the Jan Mayen area (CM), the Icelandic coastal area (CIC) in which Icelandic catches would concentrate, the East Greenland area (CG) and the Icelandic pelagic area (CIP) – see Fig. 1. The RMP adjusts the catch limits which it calculates downwards if recent catches exhibit proportions of females that exceed 50%; however this adjustment does not come into play for Central North Atlantic minke whales for which there is a slight preponderance of males in the catches.

For the CIC *Small area*, there are four aerial survey estimates (1987, 2001, 2007 and 2009) of abundance, all formally approved except for the 2009 one, which could be considered for input to the RMP. Ideally, estimates should be comparable and corrected for known biases. The 1987 estimate has been accepted by NAMMCO, an *h*(0) correction was considered unnecessary because the data collected suggested that *h*(0) was very close to 1 (0.997). The same is true of the 2001 estimate that is utilized here. It is the one-sided estimate using data from the best observer, for which *h*(0) was close to 1 and therefore not corrected. The two most recent of these estimates have also not been corrected for *h*(0). The 2007 estimate has not been corrected mainly because of lack of duplicate sightings from that survey from one of the primary observers. Two views emerged on the inclusion of the 2009 estimate in the RMP computations:

1. the *h*(0) correction was unlikely to be large, so that the 2009 estimate should be included; and
2. there were different features in the 2009 data compared to earlier years (e.g. considerably larger average radial distances to sightings), the implications of which for *h*(0) were unclear, so that the 2009 estimate should not be used until the adjustment for *h*(0) has been effected.

The WG considers that in the absence of any indication of stock structure for minke whales within the Central North Atlantic (indeed available data now suggests mixing of minke whales beyond the boundaries of this region), it would be more appropriate to treat the whole of the Central North Atlantic (CM+CIC+CIP+CG) as a *Small area* for the purposes of applying the RMP. However, this raises the difficulty that different parts of this region have been surveyed in different years. There is an approach which can adjust for this through the computation of additional variance to provide the requisite inputs for the RMP (IWC 1994). The WG **recommends** that application of this approach be pursued in the near future to provide a basis for minke whale catch limit calculations for the Central North Atlantic as a whole.

The IWC SC has recommended to their Commission, on the basis of simulation trials, that for single stocks, for which there was no stock structure uncertainty, tuning levels for the RMP ranging from 60 % to 72 % were safe from a conservation perspective in the generic case (SC/17/AS/O12). It has later been shown that all tuning levels in the interval 60 % to 70 % fulfil all criteria specified by IWC SC for a sustainable and precautionary whaling operation for minke whales (Fenstad, 1994). Table 2, (Bøthun, Institute of Marine Research, Norway, prepared for the meeting), shows the total removal levels for a single stock over this range of tuning levels. For the CIC area, the WG made additional calculations applying also the 2009 estimate. This gives the total removal levels in Table 2. The table includes catch limit estimates from both 2007 abundance estimates accepted by the NAMMCO SC. Even though there is a clear signal of decline by including the preliminary 2009 estimate, the catch limits are still dominated by the high and relatively precise 2001 estimate.

| Abundance | Tuning level | CIC | | CM |
|---|---|---|---|---|
| | | Excluding the 2009 estimate | Including the 2009 estimate | |
| | 60% tuning | | | 121 |
| | 72% tuning | | | 77 |
| Lower 2007 abundance in CIC | 60% tuning | 248 | 216 | |
| | 72% tuning | 156 | 135 | |
| Higher 2007 abundance in CIC | 60% tuning | 277 | 235 | |
| | 72% tuning | 175 | 148 | |

**Table 2.** Estimated annual total removals from the CIC and CM areas for tuning levels 0.6 and 0.72, excluding and including the abundance estimates from the 2009 survey in the CIC area.

Based on the above assessment the WG **recommends** that an advice for annual removal levels for minke whale be within the following range:

| Area | Maximum annual removals |
|---|---|
| CIC | 135 – 277 |
| CM | 77 – 121 |

The basis on which the RMP was tested indicates that any annual removals within these intervals could be applied for the next five years before a revision is needed. However, in case further data is available, including revised abundance estimates resulting from *h*(0) corrections and application of the RMP to the CM+CIC+CIP+CG areas in combination), the management advice could be revised sooner.

**5.7 Recommendations for future research**

The WG **recommended** that the 2009 survey be corrected for *h*(0) as soon as possible and that the management advice be adjusted in accordance with this estimate. The WG also recommends the 2007 aerial survey abundance estimate be corrected for *h*(0) and error in distance measurements as far as possible e.g. using the methods applied to the 2001 survey (Borchers *et al.* 2009). Line transect density should be estimated for 2007 and 2008 and 2009 surveys, along the lines of Pike *et al*. (2009a, b). For comparison, the methods used in SC/17/AS/09 should be applied to the Icelandic aerial survey data to calculate alternative corrected abundance estimates.

As there was insufficient time to calculate catch limits based on running the RMP on the Central North Atlantic medium area the WG **recommends** this be done as soon as possible.

Furthermore, the WG **recommended** that consideration should be given to redesigning the Icelandic/Faroese shipboard surveys to improve estimation of minke whale abundance in the future. This should include re-evaluation of coverage by different survey platforms (aerial/shipboard) provide improved abundance estimates for minke whales.

The WG also **recommended** that further studies on stock structure of North Atlantic minke whales should be conducted using genetic techniques and satellite tracking.

The WG **recommended** that the relationship between the fluctuations in abundance estimates around Iceland and the simultaneous ecological and environmental changes be examined for possible explanations of the suggested large-scale re-allocations of minke whales between different parts of the North Atlantic.

## 6. THE NORTH ATLANTIC FIN WHALE STOCK

### 6.1 Stock structure

This assessment is based on the various alternative stock structure hypotheses considered as plausible by the IWC SC (SC/17/AS/O07, Fig. 3) and focuses on the EG and WI small areas, which are of primary interest to the Council.

There are 7 general hypotheses regarding stock structure, as illustrated in Fig. 3:

I. Four stocks with separate feeding areas. There are four stocks with the central ‘C’ stock divided into 3 sub-stocks. The ‘W’ stock feeds in the EC and WG sub-areas, sub-stock ‘C1’ in the EG sub-area, sub-stock ‘C2’ in the WI sub-area, sub-stock ‘C3’ in the EI/F sub-area, the stock ‘E’ in the N sub-area, and stock ’S’ in the Sp sub-area.

II. Four stocks with ‘W’ and ‘E’ feeding in the central sub-areas. There are four stocks with the central stock divided into 3 sub-stocks. The ‘W’ stock feeds in sub-areas EC, WG, EG and WI, sub-stock ‘C1’ in sub-area EG, sub-stock ‘C2’ in sub-area WI, sub-stock ‘C3’ in sub-areas EI/F, stock ‘E’ in sub-areas WI, EI/F and N, and stock ‘S’ in sub-area Sp.

III. Four stocks with ‘C’ feeding in adjacent sub-areas. There are four stocks with the central stock divided into 3 sub-stocks. The ‘W’ stock feeds in sub-areas EC and WG, sub-stock ‘C1’ in sub-areas EC, WG and EG, sub-stock ‘C2’ in sub-area WI, sub-stock ‘C3’ in sub-areas EI/F and N, stock ‘E’ stock in sub-area N, and stock ‘S’ in sub-area Sp.

IV. Four stocks without sub-stock interchange. There are four stocks with the central stock divided into 3 sub-stocks, but there is no interchange between the sub-stocks. The ‘W’ stock feeds in sub-areas EC and WG; sub-stock ‘C1’ feeds in sub-areas EC, WG, EG and WI, sub-stock ‘C2’ in sub-areas EG, WI and EI/F, sub-stock ‘C3’ in sub-areas WI, EI/F and N, stock ‘E’ in sub-area N, and stock ‘S’ in sub-area Sp.

V. Four stocks with ‘S’ feeding in adjacent sub-areas. There are four stocks with the central ‘C’ stock divided into 3 sub-stocks. The stocks/sub-stocks feed as in hypothesis I except that stock ‘S’ feeds in sub-areas N and EI/F in addition to sub-area Sp.

VI. Three stocks. There are three stocks with the central ‘C’ stock divided into 3 sub-stocks. The ‘W’, ‘C1’, ‘C2’ and ‘S’ stock/sub-stocks feed as in hypothesis II. Sub-stock ‘C3’ feeds in sub-areas EI/F and N.

VII. Two stocks. There are only two stocks, with the ‘C’ stock divided into 3 sub-stocks. The ‘C1’ sub-stock feeds in sub-areas EC, WG and EG, sub-stock ‘C2’ in sub-area WI, sub-stock ‘C3’ in sub-areas EI/F and N, and stock ‘S’ in sub-area Sp.

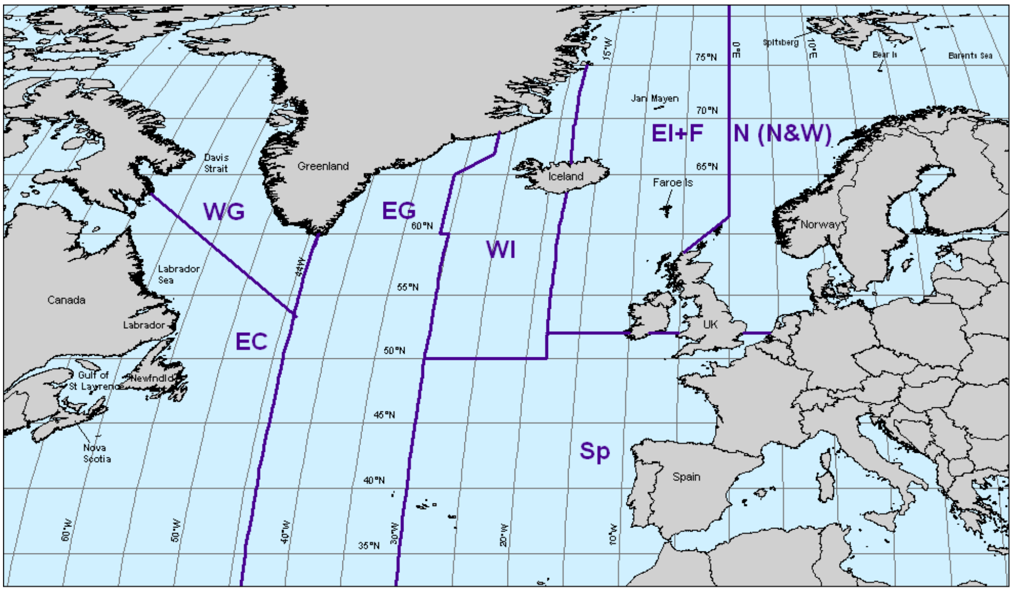


**Fig. 3.** Map of the North Atlantic showing the sub-areas defined for the North Atlantic fin whales (courtesy of the IWC).

The WG discussed especially hypothesis IV (SC/17/AS/O07) with regard to the plausibility of the biological assumptions on which it is based. Recommendations for future research were made in the light of these considerations.

### 6.2 Biological parameters

Given that the most recent assessments by the IWC SC and NAMMCO SC have been using certain values, the WG saw no reason to change them and accepted the following:

| | | |
|---|---|---|
| Plus group age, x: | 25 yrs | |
| Natural mortality, M | 0.08 $yr^{-1}$ (see also below) | |
| Age-at-first-parturition, $a_m$ | Knife-edged at age 6 | |
| Selectivity | Males | 50 a = 3.6 yrs, δ = 0.57 |
| | Females | 50 a = 4.1 yrs, δ =1.0 |
| Maximum Sustainable Yield Level (MSYL) | 0.6 (in terms of mature female component of the population) | |

### 6.3 Catch data

The catches by sub-area and year are set in assessments to one of three historical (pre-2009) series (‘best’, ‘low’ and ‘high’) as listed in IWC 2009 (Adjunct 1) (SC/17/AS/O09). The ‘best’ series includes an estimated lost whale rate of 30% in the early period (up to 1916) and allocates whales not identified to species based on the species proportions for the nearest group of years by operation or by sub-area depending on the available data. In the 'low' series none of the unspecified whales are considered fin whales whilst for the 'high' series all of the unspecified whales are taken to be fin whales. Lost whale rates of 20% and 50% are used for the 'low' and 'high' series respectively. There are no incidental catches. The sex ratio for historic catches of unknown sex and for future catches is assumed to be 50:50. Further details of the assumptions used are included in IWC 2009 (Adjunct 1) (SC/17/AS/O09).

**6.4 Abundance estimates**

The actual historical estimates of absolute abundance (and their associated CVs) used for the assessments are listed in Table 3.

| Sub-area | Year | Estimate | Sampling CV |
|---|---|---|---|
| EC | 2007 | 2,808* | 0.302 |
| WG | 1987 | 1,100 | 0.40 |
| WG | 2005 | 3,218 | 0.43 |
| WG | 2007 | 4,656 | 0.46 |
| EG | 1988 | 5,269 | 0.221 |
| EG | 1995 | 8,412 | 0.288 |
| EG | 2001 | 11,706 | 0.194 |
| WI | 1988 | 4,243 | 0.229 |
| WI | 1995 | 6,800 | 0.218 |
| WI | 2001 | 6,565 | 0.194 |
| EI+F | 1987 | 5,261 | 0.277 |
| EI+F | 1995 | 6,647 | 0.288 |
| EI+F | 2001 | 7,490 | 0.255 |
| N | 1995 | 3,964 | 0.21 |
| N | 1999 | 3,749 | 0.24 |
| Sp | 1989 | 17,355 | 0.265 |

**Table 3.** The estimates of abundance and their sampling standard errors (see Annex H of SC/17/AS/O14 for details) * the 2007 EC area estimate of 2,808 has not been used as it is uncorrected; the estimate from the Joint NAMMCO/IWC Scientific Workshop on the Catch History, Stock Structure and Abundance of North Atlantic Fin Whales (NAMMCO 2007) is used until a new estimate is available.

Some historic abundance estimates from the NASS surveys used in the North Atlantic do not cover the full sub-areas (East Greenland, West Iceland and East Iceland/Faroe Islands). The IWC SC considered sensitivity tests in which the data used in conditioning are pro-rated for these sub-areas only, by assuming the same density inside and outside of the surveyed region.

The revised (pro-rated) abundance estimates and their sampling standard errors are given in the table below (IWC 2010 and SC/17/AS/O09).

| Sub-area | Year | Estimate | Sampling CV |
|---|---|---|---|
| EG | 1988 | 5,269 | 0.221 |
| EG | 1995 | 10,152 | 0.288 |
| EG | 2001 | 14,225 | 0.194 |
| EG | 2007 | 15,847 | 0.20 |
| WI | 1988 | 4,243 | 0.229 |
| WI | 1995 | 7,363 | 0.218 |
| WI | 2001 | 7,430 | 0.194 |
| WI | 2007 | 8,898 | 0.26 |
| EI+F | 1987 | 5,261 | 0.277 |
| EI+F | 1995 | 7,170 | 0.288 |
| EI+F | 2001 | 9,555 | 0.255 |
| EI+F | 2007 | 2,466 | 0.26 |

CPUE series for some sensitivity tests are listed in Appendix 5.

In Norwegian waters, no complete abundance estimate for fin whales exist for surveys conducted after 2001. A Norwegian survey was conducted in the Svalbard area in 2008. The distribution of fin whales from this survey confirmed a trend we have seen since 1995 that fin whales in summer are more and more concentrated towards north along the continental slopes running out into the Norwegian Sea. In 2008 they were observed just off Spitsbergen. One possible explanation for this northern distribution may be the same mentioned for minke whales (section 5.4) There are further estimates for the Norwegian waters, however they are not included in the assessment because the coverage was incomplete.

**6.5 Assessments**

As part of the RMP testing process (Implementation Simulation Trials: IST), the IWC SC developed a set of assessments (operating models) corresponding to the seven stock structure hypotheses for fin whales throughout the North Atlantic mentioned in Section 6.1, and fitted these models to all the available catch, biological parameter and survey abundance estimate information across a range of MSY rates (IWC 2010). The WG considered that the results from this exercise provide appropriate assessments for the resource to be used in the formulation of management advice, as they constitute the most up-to-date analyses of their type for North Atlantic fin whales.

**6.6 Management advice**

The Commission requested advice on the estimation of sustainable catch levels for fin whales in the Central North Atlantic. Since in practice such catches would take place in the West Iceland (WI) sub-area, the WG considered that recent implementation of variants of the IWC RMP (Aldrin and Bang Huseby 2007) to calculate strike limits restricted to this sub-area provided an appropriate basis to address the Commission's request.

The two relevant RMP variants consider either only the WI sub-area, or the combination of the WI and EG (East Greenland) sub-area, as the units for which a strike limit might be calculated. The IWC SC RMP trials also show that the latter choice 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, so the WG considered that this constituted an appropriate basis for a "safe" removal recommendation.

| **Initial mature female depletion** | | | | | | |
|---|---|---|---|---|---|---|
| | **C1 sub-stock** | | **C2 sub-stock** | | **C3 sub-stock** | |
| | **5%** | **Median** | **5%** | **Median** | **5%** | **Median** |
| NF01-1 | 0.590 | 0.641 | 0.574 | 0.624 | 0.094 | 0.164 |
| NF01-2 | 0.635 | 0.714 | 0.554 | 0.636 | 0.508 | 0.608 |
| NF01-4 | 0.920 | 0.965 | 0.851 | 0.956 | 0.150 | 0.327 |
| NF02-1 | 0.451 | 0.530 | 0.439 | 0.493 | 0.294 | 0.458 |
| NF02-2 | 0.727 | 0.775 | 0.678 | 0.741 | 0.267 | 0.599 |
| NF02-4 | 0.930 | 0.954 | 0.888 | 0.945 | 0.250 | 0.342 |
| NF03-1 | 0.557 | 0.605 | 0.534 | 0.585 | 0.113 | 0.176 |
| NF03-2 | 0.802 | 0.851 | 0.755 | 0.830 | 0.138 | 0.228 |
| NF03-4 | 0.933 | 0.959 | 0.878 | 0.945 | 0.230 | 0.351 |
| NF04-1 | 0.942 | 0.950 | 0.290 | 0.344 | 0.090 | 0.165 |
| NF04-2 | 0.987 | 0.989 | 0.446 | 0.537 | 0.30 | 0.230 |
| NF04-4 | 0.998 | 0.999 | 0.632 | 0.738 | 0.135 | 0.262 |
| NF05-1 | 0.449 | 0.493 | 0.445 | 0.486 | 0.421 | 0.466 |
| NF05-2 | 0.697 | 0.730 | 0.689 | 0.720 | 0.516 | 0.609 |
| NF05-4 | 0.949 | 0.966 | 0.923 | 0.961 | 0.109 | 0.235 |
| NF06-1 | 0.566 | 0.621 | 0.553 | 0.606 | 0.139 | 0.175 |
| NF06-2 | 0.804 | 0.844 | 0.777 | 0.828 | 0.189 | 0.244 |
| NF06-4 | 0.729 | 0.836 | 0.598 | 0.687 | 0.369 | 0.511 |
| NF07-2 | 0.772 | 0.840 | 0.364 | 0.441 | 0.221 | 0.353 |
| NF07-4 | 0.923 | 0.960 | 0.496 | 0.637 | 0.295 | 0.423 |

The resultant RMP output depends on the tuning level chosen for the RMP. The IWC SC had recommended to their Commission, based on simulation trials that for single stocks for which stock structure was certain, that tuning levels ranging from 60% to 72% were safe from a conservation perspective. Further, the IWC SC RMP implementation process had extended these trials to cover stock structure uncertainty for the 72% tuning. The RMP's output is a strike limit of 87 fin whales for the 72% tuning, and 155 for the 60% tuning; the latter output is close to the earlier recommendation of the NAMMCO SC that a total annual removal of 150 whales from this population would be sustainable (NAMMCO 2007).

The WG thus **recommends** that an annual strike up to 155 fin whales from the WI Sub-area should be considered sustainable for the immediate 5-year period. However, it notes that the RMP variant with a 60% tuning level has yet to be simulation tested for trials involving stock structure uncertainty. While simple extrapolation from the results of trials mentioned above suggests that catch levels for this tuning would be safe, the WG **recommends** that the simulation trials required to check this be carried out as soon as possible, with the recommendation regarding the sustainable level of catch to be reconsidered in the light of these results. The results obtained should also be presented in the form of plots showing expected catches and conservation risks for the different tunings, so that managers are made aware of the trade-offs involved when they choose a particular tuning level.

### 6.7 Recommendations for future research

The WG **recommends** that future research should focus on further analysis on currently available data and collection of new data using tagging.

For data already available the following is **suggested**:

- Develop hypothesis incorporating dynamic density dependent mixing effect on feeding grounds in subareas WI and EG respectively. This would serve as an alternative for hypothesis 4 in the IWC implementation simulation trials.
- Compare the results from existing implementation simulation trials with CPUE data, both for the early and the middle decades of the last century. Some of the stock assessments in the implementation simulation trials seem implausible when compared to certain of these CPUE.
- Run implementation simulation trials again for different values of the tuning parameter, and present a table which shows the trade off for different tunings of catch compared to depletion levels.

The following new data collection is **suggested** to investigate the plausibility of stock structure hypothesis 4:

- **Satellite tagging:** although expected tag lifetime is short and therefore it is hard to estimate a feeding – breeding cycle, even tags on whales for only a short period would be useful to determine residency on the feeding grounds.
- **Genetic tagging:** using catches from the WI sub-area and tissue biopsies sampled in the EG sub-area, to investigate possible differences between these areas such a programme would need to continue over several years. Comparisons would be made using Hans J. Skaug's methods of estimating relatedness (SC/17/AS/O18).

Feasibility analyses should first be made for both tagging types proposals, incorporating power analysis. In both cases, the tagging effort would require a large vessel. It is therefore suggested that both tagging efforts should be conducted at the same time as the marginal cost of adding one to the other should be minimal compared with the overall cost.

## 7. NORTH ATLANTIC HUMPBACK WHALES

### 7.1 Stock structure

Heide-Jørgensen presented SC/17/AS/10. Preliminary data on satellite tracking of humpback whales in West Greenland in 2008 and 2009 were presented. A total of 34 satellite transmitters were deployed on humpback whales during summer in Disko Bay. 1The results indicate strong affinity to certain coastal localities with a later dispersal offshore on the banks. The distribution of the satellite-tracked whales matches well with the areas covered by the aerial surveys. One of the tracked humpback whales moved to the Labrador coast in August indicating affinity to the western part of the Atlantic. There was no additional new information on stock structure.

The assessment and management advice that follows is based on the assumption that humpback whales in West Greenland comprise a separate summer feeding aggregation that is best treated as a separate management unit (SC/17/AS/O06). Most of the animals in this aggregation spend the winter breeding season in the West Indies together with individuals from other summer feeding aggregations in the North Atlantic.

### 7.2 Biological parameters

No new information on biological parameters was available.

The discrete population model in the assessment used an informative prior on the survival rate, applying a Beta distributed survival rate with mean 0.957 and a SD of 0.028, in accordance with the best survival estimate for humpback whales in West Greenland (Larsen and Hammond, 2004). It also used a uniform prior on the MSYR (effectively MSYR1+) ranging from 0.01 to 0.075, with the maximum value corresponding to an IWC agreed maximal growth rate of 0.106 (IWC 2007), and a uniform prior on the MSYL from 0.5 to 0.7.

The biological parameters in the simulation trials adopted by the IWC SC were given by uniform priors from 0.9 to 0.99 for 1+ survival, from 0.5 to max(0.95, adult survival) for age class zero survival, from 4 to 7 years for the age-at-maturity, and from 2 to 3 years for the calving interval. MSYRs of 2 and 4% were applied, assuming a MSYL of 0.6.

### 7.3 Catch data

Historical catch data (Appendix 6 A-B.) were obtained from the IWC, with the assessment being based on a low and a high catch series. The low series included Greenlandic catches only (starting in 1750), and the second included also 10% of the catches in the West Indies (starting in 1664), which is twice the suggested maximum from a comparison of abundance estimates from West Greenland and the West Indies in 1992/93.

### 7.4 Abundance estimates

Heide-Jørgensen presented SC/17/AS/09 (also presented to the IWC SC and to the NAMMCO Abundance Estimates (AE) WG meeting in Québec in October 2009). Aerial line transect surveys of the density of humpback whales conducted off West Greenland eight times between 1984 and 2007 were used to estimate the rate of increase on the summer feeding ground. Only surveys in 1993, 2005 and 2007 had enough sightings to construct independent density estimates, whereas the surveys in 1987-89 and 1984-85 had to be merged and treated as two surveys. The annual rate of increase was 9.4% $yr^{-1}$ (SE=0.01) between 1984 and 2007. This rate of increase is higher than the increase observed at the breeding grounds in the West Indies, but is of the same magnitude as the observed rate of increase at other feeding grounds in the

North Atlantic. A matrix model based on observed life history parameters revealed that the theoretical growth rate of a humpback whale population ranged between 1% and 11%. This confirms that the observed growth in West Greenland is within the plausible values. The survey in 2007 was used to make a fully corrected abundance estimate including corrections for whales that were submerged during the passage of the survey plane. The line transect estimate for 2007 was 1,020 (CV=0.35). When the estimate was corrected for perception bias with mark-recapture distance sampling (MRDS) methods, the abundance increased to 1,505 (CV =0.49). Correction for availability bias was developed based on time-depth-recorder information on the time spent at the surface (0-4 m). However, used directly this correction leads to a positively-biased abundance estimate and instead a correction was developed for the non-instantaneous visual sighting process in an aircraft. The resulting estimate for 2007 was 3,270 (CV =0.50) for the MRDS analysis. An alternative strip census estimate deploying a strip width of 300 m resulted in 995 (0.33) whales including correction for perception bias. Correcting this for the same availability bias as for the MRDS method resulted in a fully corrected estimate of 2,154 (CV =0.36) humpback whales in West Greenland in 2007.

The 3,270[4] (CV =0.50) estimate was accepted by the NAMMCO AE WG (meeting in Québec in October 2009) with no comment on the time series of uncorrected estimates. However, it was noted that similar or even higher apparent rates of increase have been observed for this species in other areas, including Iceland (Pike *et al.* 2005, 2009a) and Antarctica (Matsuoka *et al.* MS 2004).

The time series of uncorrected abundance estimates is given in Table 3 together with a time series of IWC-accepted mark-recapture estimates from 1988 to1992 (Larsen and Hammond 2000).

| Year | M | S |
|---|---|---|
| 1984 | | 138 (0.28) |
| 1988 | 357 (0.16) | 231 (0.11) |
| 1989 | 355 (0.12) | |
| 1991 | 376 (0.19) | |
| 1992 | 348 (0.12) | |
| 1993 | | 873 (0.53) |
| 2005 | | 1,158 (0.35) |
| 2007 | | 1,020 (0.35) |

**Table 3.** The time-series of uncorrected mark-recapture (M) and survey (S) abundance estimates for West Greenland humpback whales, with the CV given in parenthesis.

### 7.5 Assessments

Using a discrete population model, SC/17/AS/O05 presented a Bayesian assessment for humpback whales off West Greenland based on the time series of survey abundance estimates, and the time series of mark-recapture estimates from the late 1980s and early

[4] Subsequently a revised estimate 3,272 (1,230-8,710) pa was approved after the meeting.

1990s. The assessment attempted to determine both the current trend in abundance as well as the population dynamic processes that operate on the longer timescale by applying both a density-regulated and an inertia model on the longer timescale of the complete catch history, and an exponential and density regulated model on the shorter timescale of the last two decades. It was found that there is statistically decisive support for the rejection of the density-regulated model as an appropriate model of the long-term dynamics of humpback whales off West Greenland. The dynamics are better described by the damped cyclic dynamics of the inertia model, although the density-regulated, as well as the exponential, model provide good fits when the model is initialized recently (last two decades). The assessment estimated an equilibrium population abundance between 1,700 (90% CI, 1,500 to 2,000) and 2,700 (90% CI, 2,300 to 3,100) whales, a 2008 depletion ratio between 0.88 (90% CI, 0.44 to 1.6) and 1.3 (90% CI, 0.71 to 2.4), a 2008 exponential growth rate of 0.09 (90% CI, 0.06 to 0.11), and a 2008 replacement yield between 160 (90% CI, 72 to 370) and 220 (90% CI, 96 to 510) whales per year.

The WG noted that the problem identified above of explaining the long-term dynamics of West Greenland humpback whales with a traditional density regulated model is consistent with earlier findings on the long-term dynamics of humpback whales throughout the North Atlantic (IWC, 2002, 2003).

### 7.6 Management procedure

Following the recommendation from the WG meeting in 2009, this WG found that the AWMP-C procedure (SC/17/AS/O22; SC/17/AS/O23) would be appropriate for providing management advice for West Greenland humpback whales. For a need of up to 20 humpback whales, this procedure sets the yearly strike limit for a five year period equal to 2% of the lower 5$^{th}$ percentile of the most recent abundance estimate.

The procedure has been simulation tested for long-term (100 years) performance on West Greenland humpback whales. This testing was based on trials that assume a yearly need of 10 to 20 whales, a MSYR of 2% and 4%, a MSYL from 0.5 to 0.8, a 1970 depletion from 0.2 to 0.8, and a 2008 abundance of 600, 1,300 and 2,500 whales (SC/17/AS/O23). The conservation criterion was met by the procedure for all trials with a final population depletion well above 60% of the carrying capacity at the end of the simulation period.

### 7.7 Management advice

The WC was requested to assess the sustainability of yearly catches of 5, 10, 20 humpback whales off West Greenland. ***Using the fully corrected 2007 estimate of 3,270[5] (CV =0.50) humpback whales off West Greenland, the AWMP-C procedure conclude that strikes of up to 20 humpback whales per year from 2010 to 2015 would be safe.*** This number is not to be compared directly with the lower 90% credibility estimate of the replacement yield (72-96 whales per year). The estimate of replacement yield is based not only on the current abundance but also on the estimated increase in abundance, while the AWMP-C procedure was constructed to ensure safe long-term

[5] Subsequently a revised estimate 3,272 (1,230-8,710) pa was approved after the meeting.

catches for humpback whales given a need of up to 20 humpback whales per year. The WG noted that the assessment conclude that the probability that humpback whales off West Greenland will continue to increase is larger than 0.99, even with a total annual removal of 20 whales over a five year period.

### 7.8 Recommendations for research

Should management advice on West Greenland humpback whales turn out to be a reoccurring request to the SC, the WG noted the need to consider more detailed simulation testing of the AWMP-C procedure, including a change of the procedure to apply a time-series of abundance estimates rather than just the most recent estimate. Such testing should be carried out before the procedure is used for the third time to provide management advice for a five-year period.

The WG **recommended** to:

- Investigate the stock structure using DNA sampling in order to elucidate exchange of whales with other areas of the North Atlantic and the West Greenland feeding ground
- Continue efforts for satellite tagging to determine site fidelity in West Greenland and migratory destination in winter of the humpback whales from Greenland

## 8. THE NORTH ATLANTIC SEI WHALE

### 8.1 Review of available information on stock structure

Víkingsson presented document SC/17/AS/04. Like for most other baleen whales there is considerable uncertainty about stock structure of sei whales in the North Atlantic. On the basis of relatively little evidence, the IWC defined 3 sei whale management areas:

1. Iceland-Denmark Strait;
2. Eastern (west of Norway, the Scottish Islands, Spain and Portugal);
3. Nova Scotia.

The available genetic data showed that the Icelandic sei whale represented homogenous population with no significant temporal variation in samples from 1995-1998. The great variation revealed by the DNA fingerprinting method indicates that sei whales have not undergone bottleneck effect. Recent satellite tagging of 7 sei whales during spring off the Azores showed movements of all animals to the Labrador Sea and West Greenland waters. The seasonal occurrence of this species in Icelandic waters is less regular than that for minke and fin whales and generally highest in late summer and fall. Because of this seasonal difference in peak abundance between sei whales and most other large cetaceans, it is problematic to incorporate sei whales as target species in multi-species sightings surveys normally occurring in July. However, in NASS-89 special emphasis was placed on obtaining information on distribution and abundance of sei whales (Sigurjónsson *et al*. 1991; NAMMCO 1998) by surveying farther south in the Central N-Atlantic and later in the season (from July 10. to August 14) covering a large part of the Iceland-Denmark Strait schedule stock area. A resulting abundance estimate was 10,300 animals (CV =0.268) (Cattanach *et al*. 1993). This estimate was therefore considered to be downward biased as the survey clearly only covered part of the distribution area with an unknown number in the unsurveyed area to the south. The mid-summer exception is the 1995 survey which had around 4 times higher sighting rates in overlapping areas and gave an estimate of 9,249 (Borchers and Burt 1997) sei whales in an area that only comprises 30% of the area on which the 1989 survey was based. The 2007 T-NASS covered an area in the central Atlantic similar to the 2001 survey with a similar distribution of sightings.. A total of 63 sei whale sightings were made in the TNASS, 44 of these coming from the area south and southwest of Iceland. In addition, 18 sei whales sighting were made off the west European coast (CODA) and six in the SNESSA survey off USA's east coast. The SC has recommended a joint analysis of these surveys to produce an estimate of abundance for 2007. According to the authors, a proper assessment of North Atlantic sei whales including estimation of maximum yield rates is problematic, mainly because recent abundance estimates have only partially covered the distribution area. However, the available data should be sufficient for an assessment provided that the resulting yield rates should be considered a minimum due to incomplete abundance estimation. According to an assessment conducted by the IUCN specialist group in 2008, the status of North Atlantic sei whales is good with present abundance higher than in the 1930s.

Gunnlaugsson presented document SC/17/AS/08. Markings of sei whales off Iceland took mainly place in late August and September 1979 to 1981 southwest of Iceland on the whaling grounds over or west of the Mid Atlantic Reykjanes Ridge. In total 66 whales were reported marked and 10 of these were later recovered in the catch taken on the grounds west and east of the Ridge in the autumn from the single land station in Hvalfjörður, South West Iceland. The last catches were taken in 1988. In addition two whales were marked at East Greenland in 1981 but neither recovered. Sei whale sightings in 0-group autumn surveys 1990-95 show that sei whales are not confined or concentrated in the marking area (whaling area) but have a relatively uniform distribution South West of Iceland over to South East Greenland. Surveys in the North Atlantic in mid summer and in 1989 in July to early August south to 50°N show a continuum of sightings in the area south of Iceland and even highest densities at the southern limit. 30 sei whales were marked in Canadian waters during 1960 to 1978 but none of these was recovered in the catch off Iceland. The markings farthest north on the grounds have the highest rate of recovery and recoveries are absent from markings farthest south and in the catches taken farthest east on the grounds south of Iceland. The rate of recovery falls quickly with time though mortalities were accounted for. These results are similar to those from more numerous fin whale markings in this area. The markings are clearly at the northern limit of the distribution range of the species and must be gradually diffusing into and diluted by incoming animals from the larger stock estimated roughly 10,000 animals in the midsummer surveyed area, but possibly significantly larger.

**8.2 Review of available information on biological parameter and catch data**

Historical catches and biological parameters for sei whales in the North Atlantic are adequately documented for an assessment.

**8.3 Review of available information on abundance estimates**

***Norway***

Øien informed the group that only two sightings of sei whales had been made on the Norwegian surveys. This does, however, not mean that sei whales are absent. From incidental sightings it is known that sei whales occur in Norwegian waters up to Svalbard. Sei whales were also part of the catches from land stations in northern Norway since 1885.

***Iceland/Faroe Islands***

Peak abundance of sei whales in Icelandic and adjacent waters is later in the season than for other baleen whales and thus the regular mid-summer (July) surveys are incomplete in coverage with regard to sei whales. In 1989, special emphasis was placed on obtaining information on distribution and abundance of sei whales (Sigurjónsson *et al*. 1991; NAMMCO 1998) by surveying farther south in the Central North Atlantic and later in the season. The resulting abundance estimate was 10,300 animals (CV =0.268) (Cattanach *et al.* 1993). From the NASS-95 mid-summer survey, an estimate of 9,249 sei whales was derived (Borchers and Burt 1997). The NAMMCO SC has previously recommended that abundance estimate for sei whales be calculated from the TNASS, CODA and SNESSA (2007) survey data.

***Greenland***

Heide-Jørgensen presented a published paper (SC/17/AS/O15) which contains abundance estimates of sei whales based on a ship-based survey from 2005. The estimated abundance in East Greenland (763, 95% CI, 236 to 2,465) was lower than in West Greenland (1,599, 95% CI, 690 to 3,705).

**8.4 Assessments**

The objective of this meeting was not to conduct an assessment but rather to summarize available data to evaluate the feasibility of conducting an assessment. As for other baleen whale species in the North Atlantic, there is considerable uncertainty surrounding stock structure of sei whales in the area. The main obstacle to conducting an assessment on this species might appear to be lack of recent abundance estimates. However, two sei whale abundance estimates are available from the NASS surveys in the Central North Atlantic (1989 and 1995) and one more could be produced from the 2007 surveys. In addition, estimates for East and West Greenland area are available from the 2005 survey. Although incomplete in temporal and spatial coverage, these could be used as minimum estimates in assessments. In conclusion, an assessment including a minimum estimate of sustainable yield rates should be feasible once an abundance estimate from the 2007 surveys has been produced.

**8.5 Recommendations for research**

- Abundance estimate should be calculated from the 2007 survey data (TNASS; SNESSA, CODA).
- Sightings surveys, targeted at sei whales should be conducted in the Central North Atlantic during peak abundance of the species in these waters, *i.e.* late summer/fall.
- Satellite tagging of sei whales off Iceland (and all Greenland) should be conducted to complement the recent tracking off the Azores.

## 9. REVIEW OF RULES FOR INPUT DATA TO BE USED IN ASSESSMENT

The WG agreed that the purpose of these rules and guidelines is to enhance the quality and facilitate the process of providing management advice to Council. It was recognised that adequate timing in the submission of data (catch series and abundance estimates) and working papers for calculations is essential. The WG encouraged the Secretariat to use these rules as a checklist for reminding the relevant individuals of imminent submission deadlines.

The WG considers that the Management Procedure approach offers the best basis to provide recommendations for future catch levels which are safe (do not involve undue conservation risk) and sustainable. Examples of this approach are the IWC's RMP (IWC 1994) and Norway's suggested alternative (Aldrin and Bang Huseby 2007). One of these or a similar procedure might be appropriate for North Atlantic minke and fin whales. A simpler approach of this type, such as that developed by Witting (SC/17/AS/O06 and Allison *et al.* 2009), might be appropriate for cases such as humpback whales off Greenland.

NAMMCO needs to develop the capability to develop and to readily implement such approaches, particularly as there is the possibility that it may be assigned greater responsibility for the provision of advice for catches off Greenland in the near future. However the process of developing Management Procedures can be lengthy and expensive, and NAMMCO should build on what is already available, rather than necessarily attempt developments of these procedures from scratch. Thus, for example, use could be made of the existing code available in Norway for computation of catch limits using the RMP or Norway's alternative suggestion. Further although there are relatively few scientists with knowledge of the details of the code developed in the IWC Secretariat for simulation testing of Management Procedures for specific cases such as North Atlantic fin whales, some of these scientists might be available to assist with adaptations of this code to test alternative hypotheses (such as suggested density dependent mixing – see Item 6.7).

## 10. OTHER BUSINESS

There was no other business.

## 11. ADOPTION OF REPORT

A preliminary draft of this report was approved at the end of the meeting. The report was adopted by correspondence on 19 April 2010.

Appendix 1

**AGENDA**

1. OPENING REMARKS
2. ADOPTION OF AGENDA
3. APPOINTMENT OF RAPPORTEURS
4. REVIEW OF AVAILABLE DOCUMENTS AND REPORTS
5. THE CENTRAL NORTH ATLANTIC MINKE WHALE STOCK
    - 5.1. Stock structure
    - 5.2. Biological parameters
    - 5.3. Catch data
    - 5.4. Abundance estimates
    - 5.5. Assessments
    - 5.6. Management advice
    - 5.7. Recommendations for future research
6. THE NORTH ATLANTIC FIN WHALE STOCK
    - 6.1. Stock structure
    - 6.2. Biological parameters
    - 6.3. Catch data
    - 6.4. Abundance estimates
    - 6.5. Assessments
    - 6.6. Management advice
    - 6.7. Recommendations for future research
7. THE NORTH ATLANTIC HUMPBACK WHALES
    - 7.1. Stock structure
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    - 7.3. Catch data
    - 7.4. Abundance estimates
    - 7.5. Assessments
    - 7.6. Management procedure
    - 7.7. Management advice
    - 7.8. Recommendations for research
8. THE NORTH ATLANTIC SEI WHALE
    - 8.1. Review of available information on stock structure
    - 8.2. Review of available information on biological parameters and catch data
    - 8.3. Review of available information on abundance estimates
    - 8.4. Assessments
    - 8.5. Recommendations for research
9. REVIEW OF RULES FOR INPUT DATA TO BE USED IN ASSESSMENT
10. OTHER BUSINESS
11. ADOPTION OF REPORT.

Appendix 2

**LIST OF DOCUMENTS**

| **Document no** | **Agenda** | **Title** |
|---|---|---|
| SC/17/AS/00 | 1 | Practical arrangements. |
| SC/17/AS/01 | 1 | List of Participants. |
| SC/17/AS/02 | 2 | Agenda. |
| SC/17/AS/03 | 4 | List of Documents. |
| SC/17/AS/04 | 8.1 | Vikingsson and Gunnlaugsson "Sei whales in the Central Atlantic – A review of available information". |
| SC/17/AS/05 | 5.4 | Pike *et al*. "Estimates of the abundance of minke whales (*Balaenoptera acutorostrata*) from the T-NASS Icelandic and Faroese ship surveys conducted in 2007". |
| SC/17/AS/06 | 5.4 | Víkingsson and Elvarsson "Recent changes in diet composition of minke whales (*Balaenoptera acutorostrata*) in Icelandic waters". |
| SC/17/AS/07 | 5.4 | Pike *et al*. "Icelandic aerial survey 2009: Survey report and a preliminary abundance estimate for minke whales". |
| SC/17/AS/08 | 8.1 | Gunnlaugsson *et al*. "Sei whale (*Balaenoptera borealis*) discovery markings in the Central Atlantic". |
| SC/17/AS/09 | 5.7; 7.4 | Heide-Jørgensen *et al*. "Rate of increase and current abundance of humpback whales in West Greenland". |
| SC/17/AS/10 | 7.1 | Heide-Jørgensen and Laidre "Satellite tracking of humpback whales in West Greenland in 2008 and 2009 – a preliminary presentation". |
| SC/17/AS/11 | | Pike "A comparison of the distribution and abundance of minke whales in past NASS ship surveys". |
| | | |
| SC/17/AS/O01 | 6.5 | Bøthun "Potential catch limits for North Atlantic Fin Whale". |
| SC/17/AS/O02 | | IWC SC - Annex D "Report of the Sub-Committee on the Revised Management Procedure" 2009. |
| SC/17/AS/O03 | 9 | NAMMCO "Responsibilities Associated With WG Meetings And Guidelines For Data Input To Assessment Work". |
| SC/17/AS/O04 | 6.5 | IWC "Report of the 2nd intersessional Workshop of the North Atlantic Fin Whale *Implementation*". |
| SC/17/AS/O05 | 7.5 | Witting "A Bayesian assessment of West Greenland humpback whales" 2009. |
| SC/17/AS/O06 | 7.1; *7.5* | IWC "Annex E - Report of the Standing Working Group on the Aboriginal Whaling Management Procedures" 2008. |
| SC/17/AS/O07 | 6.1 | IWC "Excerpts from IWC reports regarding NA fin stock structure hypothesis IV" 2008. |

| | | |
|---|---|---|
| SC/17/AS/O08 | | IWC “Report of the Scientific Committee 61 Madeira” 2009. |
| SC/17/AS/O09 | 6.3; 6.4 | IWC “Annex B The Specifications For The Implementation Simulation Trials For North Atlantic Fin Whales” 2009. |
| SC/17/AS/O10 | 6.5 | IWC “Annex D Implementation Simulation Trial Final Conditioning Results For North Atlantic Fin Whales” 2009. |
| SC/17/AS/O11 | | IWC “Report of the Scientific Committee 60 Santiago” 2008. |
| SC/17/AS/O12 | 5.6 | IWC “Report of the Scientific Assessment Group” 2010. |
| SC/17/AS/O13 | | IUCN “Sei Whale (*Balaenoptera borealis*) Population assessment”. |
| SC/17/AS/O14 | 6.4 | IWC “Report of the First Intersessional RMP Workshop on North<br>Atlantic Fin Whales” 2008. |
| SC/17/AS/O15 | | Heide-Jørgensen, M.P., Simon, M.J. and Laidre, K.L. 2007. Estimates of large whale abundance in Greenlandic waters from a ship-based survey in 2005. J. Cetacean Res. Manage. 9(2):95-104. |
| SC/17/AS/O16 | | Laidre, K. L., Heagerty, P. J., Heide-Jørgensen, M. P., Witting, L., and Simon, M. 2009. Sexual segregation of common minke whales (*Balaenoptera acutorostrata*) in Greenland, and the influence of sea temperature on the sex ratio of catches. – ICES Journal of Marine Science, 66: 2253–2266. |
| SC/17/AS/O17 | 5.2 | IWC. Report of the Working Group on North Atlantic minke trials. Rep. Int. Whal. Commn. 42, 1992. |
| SC/17/AS/O18 | 5.1 | Skaug, H., Danielsdottir, A.K. and Vikingsson, G.A. Relateness of North Atlantic fin whales. IWC SC/58/PFI9. |
| SC/17/AS/O19 | | Astthorson, O.S., Gislason, A. and Jonsson, S. 2007. Climate variability and the Icelandic marine ecosystem. Deep-Sea Res. II. 54:2456-2477. |
| SC/17/AS/O20 | | Marine Research Institute. 2009,Lodna *Mallotus villosus* [Capelin]. Hafrannsóknir. 146:64-66. |
| SC/17/AS/O21 | 5.4 | Rose, G.A. 2005. On distributional responses of North Atlantic fish to climate change. ICES Journal of Marine Science, 62: 1360e1374. |
| SC/17/AS/O22 | 7.6 | Witting, L. 2008. Assessment update for West Greenland fin whales. IWC/SC/60/AWMP4. |
| SC/17/AS/O23 | 7.6 | IWC “Annex E - Report of the Standing Working Group on the<br>Aboriginal Whaling Management Procedure”. 2009. |

Appendix 3

## CATCH SERIES FOR MINKE WHALES FOR THE CENTRAL AREA USED IN THE ASSESSMENT.

| Year | Minke |
|---|---|
| 1974 | 90 |
| 1975 | 181 |
| 1976 | 195 |
| 1977 | 194 |
| 1978 | 198 |
| 1979 | 202 |
| 1980 | 201 |
| 1981 | 200 |
| 1982 | 212 |
| 1983 | 204 |
| 1984 | 178 |
| 1985 | 145 |
| 1986 | - |
| 1987 | - |
| 1988 | - |
| 1989 | - |
| 1990 | - |
| 1991 | - |
| 1992 | - |
| 1993 | - |
| 1994 | - |
| 1995 | - |
| 1996 | - |
| 1997 | - |
| 1998 | - |
| 1999 | - |
| 2000 | - |
| 2001 | - |
| 2002 | - |
| 2003 | 37 |
| 2004 | 25 |
| 2005 | 39 |
| 2006 | 61 |
| 2007 | 45 |
| 2008 | 38 |
| 2009 | 81 |

Appendix 4

**DEPLETION ESTIMATES FOR THE MANAGEMENT AREAS FOR MINKE WHALES (SOURCE IWC OFFICE).**

| Trial | Stk | Initial Depletion | | |
|---|---|---|---|---|
| | | Median | 5% | 96% |
| NF 1-1 | W | 0.57 | 0.43 | 0.68 |
| NF 1-1 | C1 | 0.64 | 0.59 | 0.69 |
| NF 1-1 | C2 | 0.62 | 0.57 | 0.67 |
| NF 1-1 | C3 | 0.16 | 0.09 | 0.3 |
| NF 1-1 | E | 0.18 | 0.14 | 0.22 |
| NF 1-1 | S | 0.78 | 0.69 | 0.87 |
| | | | | |
| NF 1-2 | W | 0.79 | 0.56 | 0.92 |
| NF 1-2 | C1 | 0.71 | 0.64 | 0.79 |
| NF 1-2 | C2 | 0.64 | 0.55 | 0.71 |
| NF 1-2 | C3 | 0.61 | 0.51 | 0.7 |
| NF 1-2 | E | 0.26 | 0.2 | 0.32 |
| NF 1-2 | S | 0.95 | 0.91 | 0.98 |
| | | | | |
| NF 1-4 | W | 0.96 | 0.73 | 0.99 |
| NF 1-4 | C1 | 0.96 | 0.92 | 0.98 |
| NF 1-4 | C2 | 0.96 | 0.85 | 0.97 |
| NF 1-4 | C3 | 0.33 | 0.15 | 0.68 |
| NF 1-4 | E | 0.35 | 0.27 | 0.42 |
| NF 1-4 | S | 1 | 0.99 | 1 |
| | | | | |
| NF 2-1 | W | 0.56 | 0.41 | 0.66 |
| NF 2-1 | C1 | 0.53 | 0.45 | 0.62 |
| NF 2-1 | C2 | 0.49 | 0.44 | 0.56 |
| NF 2-1 | C3 | 0.46 | 0.29 | 0.52 |
| NF 2-1 | E | 0.15 | 0.11 | 0.2 |
| NF 2-1 | S | 0.78 | 0.69 | 0.87 |
| | | | | |
| NF 2-2 | W | 0.78 | 0.58 | 0.89 |
| NF 2-2 | C1 | 0.78 | 0.73 | 0.85 |
| NF 2-2 | C2 | 0.74 | 0.68 | 0.8 |
| NF 2-2 | C3 | 0.6 | 0.27 | 0.76 |
| NF 2-2 | E | 0.2 | 0.16 | 0.26 |
| NF 2-2 | S | 0.95 | 0.91 | 0.98 |
| | | | | |
| NF 2-4 | W | 0.92 | 0.87 | 0.97 |
| NF 2-4 | C1 | 0.95 | 0.93 | 0.97 |
| NF 2-4 | C2 | 0.94 | 0.89 | 0.96 |

| Trial | Stk | Initial Depletion | | |
|---|---|---|---|---|
| | | Median | 5% | 96% |
| NF 2-4 | C3 | 0.34 | 0.25 | 0.88 |
| NF 2-4 | E | 0.36 | 0.26 | 0.4 |
| NF 2-4 | S | 1 | 0.99 | 1 |
| | | | | |
| NF 3-1 | W | 0.6 | 0.47 | 0.69 |
| NF 3-1 | C1 | 0.61 | 0.56 | 0.66 |
| NF 3-1 | C2 | 0.58 | 0.53 | 0.63 |
| NF 3-1 | C3 | 0.18 | 0.11 | 0.31 |
| NF 3-1 | E | 0.18 | 0.13 | 0.22 |
| NF 3-1 | S | 0.77 | 0.69 | 0.85 |
| | | | | |
| NF 3-2 | W | 0.84 | 0.61 | 0.93 |
| NF 3-2 | C1 | 0.85 | 0.8 | 0.89 |
| NF 3-2 | C2 | 0.83 | 0.75 | 0.86 |
| NF 3-2 | C3 | 0.23 | 0.14 | 0.41 |
| NF 3-2 | E | 0.26 | 0.2 | 0.33 |
| NF 3-2 | S | 0.95 | 0.91 | 0.97 |
| | | | | |
| NF 3-4 | W | 0.98 | 0.93 | 0.99 |
| NF 3-4 | C1 | 0.96 | 0.93 | 0.97 |
| NF 3-4 | C2 | 0.95 | 0.88 | 0.96 |
| NF 3-4 | C3 | 0.35 | 0.23 | 0.7 |
| NF 3-4 | E | 0.36 | 0.29 | 0.41 |
| NF 3-4 | S | 1 | 0.99 | 1 |
| | | | | |
| NF 4-1 | W | 0.55 | 0.4 | 0.66 |
| NF 4-1 | C1 | 0.95 | 0.94 | 0.96 |
| NF 4-1 | C2 | 0.34 | 0.29 | 0.41 |
| NF 4-1 | C3 | 0.17 | 0.09 | 0.3 |
| NF 4-1 | E | 0.18 | 0.14 | 0.22 |
| NF 4-1 | S | 0.78 | 0.7 | 0.87 |
| | | | | |
| NF 4-2 | W | 0.76 | 0.57 | 0.9 |
| NF 4-2 | C1 | 0.99 | 0.99 | 0.99 |
| NF 4-2 | C2 | 0.54 | 0.45 | 0.63 |
| NF 4-2 | C3 | 0.23 | 0.13 | 0.38 |
| NF 4-2 | E | 0.27 | 0.2 | 0.33 |
| NF 4-2 | S | 0.95 | 0.91 | 0.97 |

| Trial | Stk | Initial Depletion | | |
|---|---|---|---|---|
| | | Median | 5% | 96% |
| | | | | |
| NF 4-4 | W | 0.95 | 0.72 | 0.99 |
| NF 4-4 | C1 | 1 | 1 | 1 |
| NF 4-4 | C2 | 0.74 | 0.63 | 0.81 |
| NF 4-4 | C3 | 0.26 | 0.14 | 0.49 |
| NF 4-4 | E | 0.35 | 0.27 | 0.43 |
| NF 4-4 | S | 1 | 0.99 | 1 |
| | | | | |
| NF 5-1 | W | 0.6 | 0.51 | 0.69 |
| NF 5-1 | C1 | 0.49 | 0.45 | 0.55 |
| NF 5-1 | C2 | 0.49 | 0.45 | 0.54 |
| NF 5-1 | C3 | 0.47 | 0.42 | 0.51 |
| NF 5-1 | E | 0.05 | 0.05 | 0.15 |
| NF 5-1 | S | 0.7 | 0.66 | 0.73 |
| | | | | |
| NF 5-2 | W | 0.71 | 0.63 | 0.87 |
| NF 5-2 | C1 | 0.73 | 0.7 | 0.77 |
| NF 5-2 | C2 | 0.72 | 0.69 | 0.76 |
| NF 5-2 | C3 | 0.61 | 0.52 | 0.7 |
| NF 5-2 | E | 0.05 | 0.05 | 0.05 |
| NF 5-2 | S | 0.96 | 0.96 | 0.96 |
| | | | | |
| NF 5-4 | W | 0.97 | 0.85 | 0.99 |
| NF 5-4 | C1 | 0.97 | 0.95 | 0.98 |
| NF 5-4 | C2 | 0.96 | 0.92 | 0.97 |
| NF 5-4 | C3 | 0.24 | 0.11 | 0.49 |
| NF 5-4 | E | 0.23 | 0.1 | 0.35 |
| NF 5-4 | S | 1 | 0.99 | 1 |
| | | | | |
| NF 6-1 | W | 0.55 | 0.4 | 0.66 |
| NF 6-1 | C1 | 0.62 | 0.57 | 0.69 |
| NF 6-1 | C2 | 0.61 | 0.55 | 0.66 |
| NF 6-1 | C3 | 0.17 | 0.14 | 0.25 |
| NF 6-1 | S | 0.78 | 0.7 | 0.87 |
| | | | | |
| NF 6-2 | W | 0.78 | 0.57 | 0.89 |
| NF 6-2 | C1 | 0.84 | 0.8 | 0.88 |
| NF 6-2 | C2 | 0.83 | 0.78 | 0.87 |
| NF 6-2 | C3 | 0.24 | 0.19 | 0.38 |
| NF 6-2 | S | 0.95 | 0.91 | 0.98 |
| | | | | |
| NF 6-4 | W | 0.92 | 0.73 | 0.99 |

| Trial | Stk | Initial Depletion | | |
|---|---|---|---|---|
| | | Median | 5% | 96% |
| NF 6-4 | C1 | 0.84 | 0.73 | 0.96 |
| NF 6-4 | C2 | 0.69 | 0.6 | 0.94 |
| NF 6-4 | C3 | 0.51 | 0.37 | 0.62 |
| NF 6-4 | S | 1 | 0.99 | 1 |
| | | | | |
| NF 7-2 | C1 | 0.84 | 0.77 | 0.91 |
| NF 7-2 | C2 | 0.44 | 0.36 | 0.72 |
| NF 7-2 | C3 | 0.35 | 0.22 | 0.46 |
| NF 7-2 | S | 0.95 | 0.91 | 0.98 |
| | | | | |
| NF 7-4 | C1 | 0.96 | 0.92 | 0.98 |
| NF 7-4 | C2 | 0.64 | 0.5 | 0.91 |
| NF 7-4 | C3 | 0.42 | 0.29 | 0.58 |
| NF 7-4 | S | 1 | 0.99 | 1 |

Appendix 5

Table 7. CPUE series for North Atlantic fin whales.

| | Earlier period | | | Later period | | | |
|---|---|---|---|---|---|---|---|
| | East Iceland | West Iceland | | West Iceland | | | |
| Year | CPUE $i$=5 | CPUE $i$=6 | Year | CPUE $i$=1 | CPUE $i$=2 | CPUE $i$=3 | CPUE $i$=4 |
| 1902 | - | 24.8 | 1962 | 0.1398 | 0.1512 | 0.1048 | - |
| 1903 | - | 21.2 | 1963 | 0.1363 | 0.0841 | 0.0671 | - |
| 1904 | 1.195 | 22.9 | 1964 | 0.0770 | 0.0551 | 0.0492 | - |
| 1905 | 1.621 | 28.3 | 1965 | 0.1979 | 0.1519 | 0.1204 | - |
| 1906 | 0.894 | 18.2 | 1966 | 0.1150 | 0.1083 | 0.0863 | 0.1310 |
| 1907 | 1.122 | 16.0 | 1967 | 0.1040 | 0.1280 | 0.1798 | 0.1350 |
| 1908 | 0.971 | 16.5 | 1968 | 0.1548 | 0.0990 | 0.1314 | 0.1672 |
| 1909 | 1.228 | 25.4 | 1969 | 0.0541 | 0.0880 | 0.0691 | 0.0495 |
| 1910 | 0.733 | 18.4 | 1970 | 0.1040 | 0.1596 | 0.1466 | 0.1282 |
| 1911 | 0.739 | 16.9 | 1971 | 0.0824 | 0.0591 | 0.0523 | 0.0703 |
| 1912 | - | 9.9 | 1972 | 0.0836 | 0.0718 | 0.0648 | 0.0601 |
| 1913 | 0.496 | 5.8 | 1973 | 0.0785 | 0.0853 | 0.0708 | 0.0791 |
| 1914 | - | 7.4 | 1974 | 0.0810 | 0.1134 | 0.0861 | 0.1132 |
| | | | 1975 | 0.1115 | 0.0958 | 0.0779 | 0.1011 |
| | | | 1976 | 0.1067 | 0.0909 | 0.0993 | 0.0779 |
| | | | 1977 | 0.0296 | 0.0651 | 0.0443 | 0.0390 |
| | | | 1978 | 0.0507 | 0.0583 | 0.0732 | 0.0675 |
| | | | 1979 | 0.1817 | 0.1494 | 0.1389 | 0.1276 |
| | | | 1980 | 0.0891 | 0.0933 | 0.1317 | 0.1220 |
| | | | 1981 | 0.1572 | 0.1134 | 0.1333 | 0.1271 |
| | | | 1982 | 0.1677 | 0.1190 | 0.1094 | 0.0974 |
| | | | 1983 | 0.0804 | - | 0.0597 | 0.0837 |
| | | | 1984 | 0.1169 | - | 0.1233 | 0.1283 |
| | | | 1985 | 0.1170 | - | 0.0777 | 0.0857 |
| | | | 1986 | - | - | 0.0744 | 0.0856 |
| | | | 1987 | - | - | 0.1792 | 0.0990 |

able 8. The variance-covariance matrix for the late CLUE series obtained by quadratically detrending the log-transformed data (Butterworth and Punt 1992).

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0.171 | 0.089 | 0.102 | 0.118 |
| 2 | 0.089 | 0.103 | 0.105 | 0.076 |
| 3 | 0.102 | 0.105 | 0.156 | 0.104 |
| 4 | 0.118 | 0.076 | 0.104 | 0.127 |

Appendix 6 A

## HUMPBACK WHALE CATCH DATA WEST GREENLAND (IWC DATABASE). M=MALE; F= FEMALE.

| year | M | F |
|---|---|---|
| 1750 | 4 | 4 |
| 1751 | 4 | 4 |
| 1752 | 4 | 4 |
| 1753 | 4 | 4 |
| 1754 | 4 | 4 |
| 1755 | 4 | 4 |
| 1756 | 4 | 4 |
| 1757 | 4 | 4 |
| 1758 | 4 | 4 |
| 1759 | 4 | 4 |
| 1760 | 4 | 4 |
| 1761 | 4 | 4 |
| 1762 | 4 | 4 |
| 1763 | 4 | 4 |
| 1764 | 4 | 4 |
| 1765 | 4 | 4 |
| 1766 | 4 | 4 |
| 1767 | 4 | 4 |
| 1768 | 4 | 4 |
| 1769 | 4 | 4 |
| 1770 | 4 | 4 |
| 1771 | 4 | 4 |
| 1772 | 4 | 4 |
| 1773 | 4 | 4 |
| 1774 | 4 | 4 |
| 1775 | 4 | 4 |
| 1776 | 4 | 4 |
| 1777 | 4 | 4 |
| 1778 | 4 | 4 |
| 1779 | 4 | 4 |
| 1780 | 4 | 4 |
| 1781 | 4 | 4 |
| 1782 | 4 | 4 |
| 1783 | 4 | 4 |
| 1784 | 4 | 4 |
| 1785 | 4 | 4 |
| 1786 | 4 | 4 |
| 1787 | 4 | 4 |
| 1788 | 4 | 4 |

| year | M | F |
|---|---|---|
| 1789 | 4 | 4 |
| 1790 | 4 | 4 |
| 1791 | 4 | 4 |
| 1792 | 4 | 4 |
| 1793 | 4 | 4 |
| 1794 | 4 | 4 |
| 1795 | 4 | 4 |
| 1796 | 4 | 4 |
| 1797 | 4 | 4 |
| 1798 | 4 | 4 |
| 1799 | 4 | 4 |
| 1800 | 4 | 4 |
| 1801 | 4 | 4 |
| 1802 | 4 | 4 |
| 1803 | 4 | 4 |
| 1804 | 4 | 4 |
| 1805 | 4 | 4 |
| 1806 | 4 | 4 |
| 1807 | 4 | 4 |
| 1808 | 4 | 4 |
| 1809 | 4 | 4 |
| 1810 | 4 | 4 |
| 1811 | 4 | 4 |
| 1812 | 4 | 4 |
| 1813 | 4 | 4 |
| 1814 | 4 | 4 |
| 1815 | 4 | 4 |
| 1816 | 4 | 4 |
| 1817 | 4 | 4 |
| 1818 | 4 | 4 |
| 1819 | 4 | 4 |
| 1820 | 4 | 4 |
| 1821 | 4 | 4 |
| 1822 | 4 | 4 |
| 1823 | 4 | 4 |
| 1824 | 4 | 4 |
| 1825 | 4 | 4 |
| 1826 | 4 | 4 |
| 1827 | 4 | 4 |

| year | M | F |
|---|---|---|
| 1828 | 4 | 4 |
| 1829 | 4 | 4 |
| 1830 | 4 | 4 |
| 1831 | 4 | 4 |
| 1832 | 4 | 4 |
| 1833 | 4 | 4 |
| 1834 | 4 | 4 |
| 1835 | 4 | 4 |
| 1836 | 4 | 4 |
| 1837 | 4 | 4 |
| 1838 | 4 | 4 |
| 1839 | 4 | 4 |
| 1840 | 4 | 4 |
| 1841 | 16 | 16 |
| 1842 | 13 | 13 |
| 1843 | 13 | 13 |
| 1844 | 10 | 10 |
| 1845 | 13 | 13 |
| 1846 | 13 | 13 |
| 1847 | 13 | 13 |
| 1848 | 13 | 13 |
| 1849 | 13 | 13 |
| 1850 | 11 | 11 |
| 1851 | 13 | 13 |
| 1852 | 13 | 13 |
| 1853 | 13 | 13 |
| 1854 | 13 | 13 |
| 1855 | 13 | 13 |
| 1856 | 13 | 13 |
| 1857 | 13 | 13 |
| 1858 | 13 | 13 |
| 1859 | 13 | 13 |
| 1860 | 13 | 13 |
| 1861 | 13 | 13 |
| 1862 | 13 | 13 |
| 1863 | 13 | 13 |
| 1864 | 13 | 13 |
| 1865 | 13 | 13 |
| 1866 | 2 | 2 |

| year | M | F |
|---|---|---|
| 1867 | 2 | 2 |
| 1868 | 2 | 2 |
| 1869 | 2 | 2 |
| 1870 | 2 | 2 |
| 1871 | 2 | 2 |
| 1872 | 2 | 2 |
| 1873 | 2 | 2 |
| 1874 | 2 | 2 |
| 1875 | 2 | 2 |
| 1876 | 2 | 2 |
| 1877 | 2 | 2 |
| 1878 | 2 | 2 |
| 1879 | 2 | 2 |
| 1880 | 2 | 2 |
| 1881 | 2 | 2 |
| 1882 | 2 | 2 |
| 1883 | 2 | 2 |
| 1884 | 2 | 2 |
| 1885 | 2 | 2 |
| 1886 | 4 | 4 |
| 1887 | 4 | 4 |
| 1888 | 4 | 4 |
| 1889 | 2 | 2 |
| 1890 | 4 | 4 |
| 1891 | 4 | 4 |
| 1892 | 2 | 2 |
| 1893 | 6 | 6 |
| 1894 | 7 | 7 |
| 1895 | 6 | 6 |
| 1896 | 2 | 2 |
| 1897 | 5 | 5 |
| 1898 | 2 | 2 |
| 1899 | 5 | 5 |
| 1900 | 8 | 8 |
| 1901 | 8 | 8 |
| 1902 | 8 | 8 |
| 1903 | 8 | 8 |
| 1904 | 8 | 8 |
| 1905 | 4 | 4 |

| year | M | F |
|---|---|---|
| 1906 | 4 | 4 |
| 1907 | 4 | 4 |
| 1908 | 4 | 4 |
| 1909 | 4 | 4 |
| 1910 | 2 | 2 |
| 1911 | 6 | 5 |
| 1912 | 6 | 5 |
| 1913 | 2 | 2 |
| 1914 | 2 | 2 |
| 1915 | 2 | 2 |
| 1916 | 2 | 2 |
| 1917 | 2 | 2 |
| 1918 | 2 | 2 |
| 1919 | 8 | 6 |
| 1920 | 1 | 1 |
| 1921 | 1 | 1 |
| 1922 | 88 | 57 |
| 1923 | 95 | 59 |
| 1924 | 28 | 20 |
| 1925 | 4 | 4 |
| 1926 | 6 | 6 |
| 1927 | 5 | 6 |
| 1928 | 4 | 5 |
| 1929 | 5 | 5 |
| 1930 | 19 | 12 |
| 1931 | 13 | 10 |
| 1932 | 5 | 4 |
| 1933 | 3 | 2 |
| 1934 | 2 | 2 |
| 1935 | 3 | 3 |
| 1936 | 2 | 3 |
| 1937 | 8 | 5 |
| 1938 | 0 | 1 |
| 1939 | 1 | 1 |
| 1940 | 0 | 0 |
| 1941 | 0 | 0 |
| 1942 | 0 | 0 |
| 1943 | 0 | 0 |
| 1944 | 0 | 0 |
| 1945 | 0 | 0 |
| 1946 | 2 | 2 |
| 1947 | 2 | 3 |
| 1948 | 0 | 1 |
| 1949 | 1 | 1 |

| year | M | F |
|---|---|---|
| 1950 | 1 | 2 |
| 1951 | 2 | 3 |
| 1952 | 0 | 0 |
| 1953 | 0 | 1 |
| 1954 | 0 | 0 |
| 1955 | 0 | 0 |
| 1956 | 0 | 0 |
| 1957 | 0 | 0 |
| 1958 | 0 | 0 |
| 1959 | 0 | 0 |
| 1960 | 0 | 1 |
| 1961 | 0 | 1 |
| 1962 | 1 | 1 |
| 1963 | 0 | 0 |
| 1964 | 0 | 0 |
| 1965 | 0 | 1 |
| 1966 | 2 | 2 |
| 1967 | 2 | 2 |
| 1968 | 2 | 3 |
| 1969 | 1 | 2 |
| 1970 | 0 | 0 |
| 1971 | 2 | 2 |
| 1972 | 1 | 2 |
| 1973 | 5 | 6 |
| 1974 | 4 | 5 |
| 1975 | 4 | 5 |
| 1976 | 4 | 5 |
| 1977 | 8 | 9 |
| 1978 | 12 | 12 |
| 1979 | 7 | 8 |
| 1980 | 8 | 8 |
| 1981 | 6 | 6 |
| 1982 | 6 | 6 |
| 1983 | 7 | 9 |
| 1984 | 8 | 8 |
| 1985 | 4 | 4 |
| 1986 | 0 | 0 |
| 1987 | 0 | 0 |
| 1988 | 0 | 1 |
| 1989 | 1 | 1 |
| 1990 | 0 | 1 |
| 1991 | 0 | 1 |
| 1992 | 0 | 1 |
| 1993 | 0 | 0 |

| year | M | F |
|---|---|---|
| 1994 | 0 | 1 |
| 1995 | 0 | 0 |
| 1996 | 0 | 0 |
| 1997 | 0 | 0 |
| 1998 | 0 | 1 |
| 1999 | 0 | 1 |
| 2000 | 0 | 2 |
| 2001 | 1 | 1 |
| 2002 | 2 | 1 |
| 2003 | 0 | 1 |
| 2004 | 2 | 1 |
| 2005 | 2 | 3 |
| 2006 | 0 | 0 |
| 2007 | 1 | 1 |

Appendix 6 B

**HUMPBACK WHALE CATCH DATA WEST INDIES (IWC DATABASE).**
**M=MALE; F= FEMALE.**

| year | M | F |
|---|---|---|
| 1664 | 2 | 5 |
| 1665 | 9 | 21 |
| 1666 | 5 | 12 |
| 1667 | 7 | 19 |
| 1668 | 2 | 5 |
| 1669 | 5 | 12 |
| 1670 | 5 | 12 |
| 1671 | 5 | 12 |
| 1672 | 5 | 12 |
| 1673 | 5 | 12 |
| 1674 | 5 | 12 |
| 1675 | 5 | 12 |
| 1676 | 5 | 12 |
| 1677 | 5 | 12 |
| 1678 | 5 | 12 |
| 1679 | 0 | 0 |
| 1680 | 0 | 0 |
| 1681 | 0 | 0 |
| 1682 | 0 | 0 |
| 1683 | 0 | 0 |
| 1684 | 0 | 0 |
| 1685 | 7 | 19 |
| 1686 | 7 | 19 |
| 1687 | 7 | 19 |
| 1688 | 7 | 19 |
| 1689 | 7 | 19 |
| 1690 | 7 | 19 |
| 1691 | 4 | 11 |
| 1692 | 7 | 19 |
| 1693 | 7 | 19 |
| 1694 | 7 | 19 |
| 1695 | 7 | 19 |
| 1696 | 7 | 19 |
| 1697 | 7 | 19 |
| 1698 | 7 | 19 |
| 1699 | 7 | 19 |
| 1700 | 7 | 19 |
| 1701 | 7 | 19 |
| 1702 | 7 | 19 |

| year | M | F |
|---|---|---|
| 1703 | 7 | 19 |
| 1704 | 7 | 19 |
| 1705 | 7 | 19 |
| 1706 | 7 | 19 |
| 1707 | 7 | 19 |
| 1708 | 7 | 19 |
| 1709 | 7 | 19 |
| 1710 | 7 | 19 |
| 1711 | 7 | 19 |
| 1712 | 7 | 19 |
| 1713 | 7 | 19 |
| 1714 | 7 | 19 |
| 1715 | 7 | 19 |
| 1716 | 7 | 19 |
| 1717 | 7 | 19 |
| 1718 | 7 | 19 |
| 1719 | 7 | 19 |
| 1720 | 7 | 19 |
| 1721 | 7 | 19 |
| 1722 | 7 | 19 |
| 1723 | 7 | 19 |
| 1724 | 7 | 19 |
| 1725 | 7 | 19 |
| 1726 | 7 | 19 |
| 1727 | 7 | 19 |
| 1728 | 7 | 19 |
| 1729 | 7 | 19 |
| 1730 | 7 | 19 |
| 1731 | 7 | 19 |
| 1732 | 7 | 19 |
| 1733 | 7 | 19 |
| 1734 | 7 | 19 |
| 1735 | 7 | 19 |
| 1736 | 7 | 19 |
| 1737 | 7 | 19 |
| 1738 | 7 | 19 |
| 1739 | 7 | 19 |
| 1740 | 7 | 19 |
| 1741 | 7 | 19 |

| year | M | F |
|---|---|---|
| 1742 | 7 | 19 |
| 1743 | 7 | 19 |
| 1744 | 7 | 19 |
| 1745 | 7 | 19 |
| 1746 | 7 | 19 |
| 1747 | 7 | 19 |
| 1748 | 11 | 26 |
| 1749 | 7 | 19 |
| 1750 | 7 | 19 |
| 1751 | 2 | 3 |
| 1752 | 2 | 3 |
| 1753 | 2 | 3 |
| 1754 | 2 | 3 |
| 1755 | 2 | 3 |
| 1756 | 2 | 3 |
| 1757 | 2 | 3 |
| 1758 | 2 | 3 |
| 1759 | 2 | 3 |
| 1760 | 2 | 3 |
| 1761 | 2 | 3 |
| 1762 | 2 | 3 |
| 1763 | 2 | 3 |
| 1764 | 2 | 3 |
| 1765 | 2 | 3 |
| 1766 | 2 | 3 |
| 1767 | 2 | 3 |
| 1768 | 2 | 3 |
| 1769 | 2 | 3 |
| 1770 | 2 | 3 |
| 1771 | 2 | 3 |
| 1772 | 2 | 3 |
| 1773 | 2 | 3 |
| 1774 | 2 | 3 |
| 1775 | 2 | 3 |
| 1776 | 2 | 3 |
| 1777 | 2 | 3 |
| 1778 | 2 | 3 |
| 1779 | 2 | 3 |
| 1780 | 0 | 2 |

| year | M | F |
|---|---|---|
| 1781 | 0 | 2 |
| 1782 | 0 | 2 |
| 1783 | 0 | 2 |
| 1784 | 0 | 2 |
| 1785 | 0 | 2 |
| 1786 | 2 | 3 |
| 1787 | 2 | 3 |
| 1788 | 2 | 3 |
| 1789 | 2 | 3 |
| 1790 | 2 | 3 |
| 1791 | 2 | 3 |
| 1792 | 2 | 3 |
| 1793 | 2 | 3 |
| 1794 | 2 | 3 |
| 1795 | 2 | 3 |
| 1796 | 2 | 3 |
| 1797 | 0 | 0 |
| 1798 | 2 | 3 |
| 1799 | 2 | 3 |
| 1800 | 2 | 3 |
| 1801 | 2 | 3 |
| 1802 | 2 | 3 |
| 1803 | 2 | 3 |
| 1804 | 2 | 3 |
| 1805 | 2 | 3 |
| 1806 | 2 | 3 |
| 1807 | 2 | 3 |
| 1808 | 2 | 3 |
| 1809 | 2 | 3 |
| 1810 | 2 | 3 |
| 1811 | 2 | 3 |
| 1812 | 2 | 3 |
| 1813 | 2 | 3 |
| 1814 | 2 | 3 |
| 1815 | 2 | 3 |
| 1816 | 2 | 3 |
| 1817 | 2 | 3 |
| 1818 | 2 | 3 |
| 1819 | 2 | 3 |

| year | M | F | year | M | F | year | M | F | year | M | F |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1820 | 2 | 3 | 1864 | 39 | 38 | 1908 | 13 | 31 | 1952 | 0 | 0 |
| 1821 | 2 | 3 | 1865 | 133 | 111 | 1909 | 6 | 15 | 1953 | 0 | 0 |
| 1822 | 2 | 3 | 1866 | 134 | 116 | 1910 | 4 | 11 | 1954 | 0 | 0 |
| 1823 | 2 | 3 | 1867 | 196 | 169 | 1911 | 4 | 11 | 1955 | 0 | 0 |
| 1824 | 2 | 3 | 1868 | 123 | 105 | 1912 | 5 | 13 | 1956 | 0 | 0 |
| 1825 | 2 | 3 | 1869 | 81 | 72 | 1913 | 3 | 8 | 1957 | 0 | 0 |
| 1826 | 7 | 18 | 1870 | 58 | 52 | 1914 | 2 | 6 | 1958 | 3 | 6 |
| 1827 | 6 | 14 | 1871 | 53 | 66 | 1915 | 4 | 11 | 1959 | 3 | 6 |
| 1828 | 2 | 5 | 1872 | 72 | 76 | 1916 | 6 | 15 | 1960 | 0 | 2 |
| 1829 | 3 | 6 | 1873 | 60 | 67 | 1917 | 3 | 8 | 1961 | 0 | 0 |
| 1830 | 9 | 22 | 1874 | 78 | 86 | 1918 | 3 | 8 | 1962 | 0 | 0 |
| 1831 | 9 | 20 | 1875 | 98 | 102 | 1919 | 9 | 20 | 1963 | 2 | 4 |
| 1832 | 15 | 37 | 1876 | 99 | 101 | 1920 | 9 | 20 | 1964 | 0 | 2 |
| 1833 | 11 | 26 | 1877 | 93 | 97 | 1921 | 2 | 3 | 1965 | 0 | 2 |
| 1834 | 20 | 50 | 1878 | 96 | 114 | 1922 | 7 | 19 | 1966 | 0 | 0 |
| 1835 | 18 | 43 | 1879 | 81 | 85 | 1923 | 5 | 12 | 1967 | 2 | 4 |
| 1836 | 16 | 38 | 1880 | 86 | 95 | 1924 | 7 | 17 | 1968 | 2 | 4 |
| 1837 | 16 | 38 | 1881 | 78 | 88 | 1925 | 86 | 23 | 1969 | 2 | 4 |
| 1838 | 20 | 48 | 1882 | 54 | 74 | 1926 | 60 | 20 | 1970 | 4 | 11 |
| 1839 | 13 | 33 | 1883 | 65 | 76 | 1927 | 2 | 3 | 1971 | 2 | 4 |
| 1840 | 17 | 42 | 1884 | 84 | 128 | 1928 | 3 | 8 | 1972 | 3 | 8 |
| 1841 | 16 | 40 | 1885 | 66 | 97 | 1929 | 2 | 6 | 1973 | 0 | 2 |
| 1842 | 16 | 38 | 1886 | 94 | 172 | 1930 | 2 | 3 | 1974 | 0 | 2 |
| 1843 | 16 | 38 | 1887 | 29 | 74 | 1931 | 2 | 6 | 1975 | 0 | 0 |
| 1844 | 12 | 29 | 1888 | 11 | 28 | 1932 | 2 | 4 | 1976 | 0 | 2 |
| 1845 | 14 | 35 | 1889 | 16 | 39 | 1933 | 2 | 3 | 1977 | 0 | 0 |
| 1846 | 13 | 33 | 1890 | 20 | 48 | 1934 | 2 | 3 | 1978 | 0 | 2 |
| 1847 | 4 | 11 | 1891 | 16 | 38 | 1935 | 2 | 6 | 1979 | 2 | 5 |
| 1848 | 20 | 50 | 1892 | 13 | 33 | 1936 | 2 | 3 | 1980 | 1 | 3 |
| 1849 | 15 | 37 | 1893 | 25 | 60 | 1937 | 2 | 3 | 1981 | 0 | 0 |
| 1850 | 23 | 37 | 1894 | 16 | 38 | 1938 | 2 | 3 | 1982 | 2 | 3 |
| 1851 | 19 | 33 | 1895 | 18 | 45 | 1939 | 2 | 6 | 1983 | 0 | 2 |
| 1852 | 48 | 54 | 1896 | 18 | 45 | 1940 | 0 | 2 | 1984 | 0 | 0 |
| 1853 | 50 | 61 | 1897 | 47 | 114 | 1941 | 2 | 3 | 1985 | 0 | 0 |
| 1854 | 42 | 50 | 1898 | 8 | 20 | 1942 | 0 | 2 | 1986 | 0 | 2 |
| 1855 | 60 | 65 | 1899 | 20 | 51 | 1943 | 0 | 0 | 1987 | 0 | 2 |
| 1856 | 74 | 77 | 1900 | 27 | 68 | 1944 | 0 | 0 | 1988 | 0 | 2 |
| 1857 | 60 | 65 | 1901 | 38 | 94 | 1945 | 0 | 0 | 1989 | 0 | 0 |
| 1858 | 60 | 63 | 1902 | 31 | 75 | 1946 | 0 | 0 | 1990 | 0 | 0 |
| 1859 | 46 | 48 | 1903 | 29 | 73 | 1947 | 0 | 2 | 1991 | 0 | 0 |
| 1860 | 39 | 47 | 1904 | 9 | 23 | 1948 | 2 | 4 | 1992 | 0 | 2 |
| 1861 | 35 | 42 | 1905 | 7 | 15 | 1949 | 0 | 0 | 1993 | 0 | 2 |
| 1862 | 27 | 30 | 1906 | 11 | 26 | 1950 | 0 | 0 | 1994 | 0 | 0 |
| 1863 | 42 | 40 | 1907 | 9 | 25 | 1951 | 0 | 0 | 1995 | 0 | 0 |

| year | M | F |
|---|---|---|
| 1996 | 0 | 2 |
| 1997 | 0 | 0 |
| 1998 | 0 | 2 |
| 1999 | 0 | 2 |
| 2000 | 0 | 2 |
| 2001 | 0 | 2 |

ANNEX 5

# REPORT OF THE NAMMCO SCIENTIFIC COMMITTEE INTER-SESSIONAL MEETING ON WALRUS

By request from Council, the Scientific Committee considered the report of the Working Group (WG) meeting (NAMMCO/19/6 Annex 2) by correspondence December 8 -14. Appendix 1 lists those participating. An email correspondence meeting is certainly not optimal, and these kinds of inter-sessional reviews should, if possible, be avoided in the future. A full discussion of the context and implications of a WG meeting with management advice is best performed at the annual meeting of the Scientific Committee (SC).

The NAMMCO Scientific Committee Working Group on Walrus met November 23-26 at the Greenland Representation in Copenhagen, Denmark, to evaluate the status of walrus stocks in Greenland and adjacent seas. The purpose of the meeting was to address the following requests for advice from the NAMMCO Council (NAMMCO 15, 16 and 17):

**R-2.6.3 (NAMMCO/15-2006):** The SC was asked to provide advice on the 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.

**R-2.6.4 (NAMMCO/16-2007):** The SC was requested to provide a formal assessment of the Davis Strait (walrus) stock as soon as finalization of the catch series is complete and the results from the planned 2007 survey are available. The SC was then requested to provide estimate of sustainable yields for the North Water and West Greenland stocks of walrus.

**R-2.6.5 (NAMMCO/17-2008):** The SC was requested to provide a full assessment of the North Water, West Greenland-Eastern Baffin Island and East Greenland (walrus) stocks.

The SC had last reviewed the status of the stocks in 2005. At that time it was not in position to complete an assessment of any stock and provide advice on sustainable harvests because of the uncertainty in or lack of input data, in particular in relation to stock structure, abundance and catch series. It identified essential points of research which had to be completed before progress in the assessment could be made (NAMMCO 2006).

Considering the progress since 2005, the SC tasked the Scientific Committee Working Group on Walrus to perform its review and evaluate the status of walrus stocks in Greenland and adjacent seas, with focus on the three requests.

## STOCK STRUCTURE AND MANAGEMENT UNITS

The SC agreed on a revised stock structure for walrus in Greenland and Canada based on new, though still somewhat limited, data which had become available in particular through genetic analyses and satellite telemetry.

From a management perspective walruses in the North Water Polynya (NOW) in northern Baffin Bay and the Canadian High Arctic are best treated as 3 stocks given our current state of knowledge: 1) Penny Strait – Lancaster Sound; 2) western Jones Sound; and 3) northern Baffin Bay (BB). The SC noted that movement of walruses with satellite radios and conventional tags confirmed the information from a genetic study that established a link between the West Greenland and Southeast Baffin Island animals and that there is a possibility of a limited movement of individuals northwards from West Greenland. The SC concluded that walruses in West Greenland and at Southeast Baffin Island constitute a single stock. The Hudson Strait stock is also linked to this complex to at least a limited degree. For management purposes "West Greenland – S.E. Baffin Island" and "Baffin Bay" should be considered as two separate stocks. In East Greenland walruses are mainly concentrated north of 73°30´ N and there is little evidence of a connection with the Svalbard – Franz Josef Land walruses. This latter stock is believed to be separate from the stocks further south and east in the Russian waters of Novaya Zemlya, Pechora and Kara seas.

## CATCH STATISTICS

The SC noted that the reported catch from Nunavut (Canada) is at best a rough estimate and that it is unlikely to be an overestimate. Data about struck and lost animals in Nunavut were not presented. Information on reported catch (1993-2008) and struck-and-lost in the Greenland walrus catch was provided by the Agency of Fisheries, Hunting and Agriculture (AFHA) of the Greenland Government. According to AFHA, all catch data from 1993-2004 had been checked and data from 2005-2008 reported in the reporting system "*Piniarneq*" had been cross-checked with data in the special reporting forms to be filled-out by the hunters and delivered after each walrus catch. This validation of the data since 2005 has been carried out by the AFHA with telephone interviews with each individual walrus hunter. Only one walrus was reported struck-and-lost in the reporting period between 2006 (when quotas were introduced) and 2008; an implausible low number. Recent catch data from Greenland in addition to historical catch series (Witting and Born 2005: ICES Journal of Marine Science 62: 266-284) and catches reported for S.E. Baffin Island and Jones Sound in Canada were used in the assessment of the three walrus stocks that range in Greenland.

The SC noted its requirement from 2005 that accurate catch series, including correction for "struck and lost" and underreporting, be provided and that the accuracy of the recent harvest reports be evaluated. Some progress had been made in Greenland on the old catch series, but data on 'struck and lost' are still missing for all areas. Although the reporting system starting in 2005 is likely better than the old system, an evaluation of the accuracy of the system had not been provided. In particular, the SC noted an implausible low reporting of "struck and loss" and an apparent problematic reporting of caught females as males.

The SC regrets this situation and reiterated its recommendation of gathering reliable harvest data, including struck-and-lost, underreporting, and correct sex determination. It expressed concern that the existing reporting in Canada and Greenland is not working satisfactorily in this regard.

## ABUNDANCE AND TRENDS

Recent abundance estimates of stocks in Greenland, Canada and Svalbard based on boat and aerial surveys are presented in Table 1.

| Stock | Year | Season | N (number) | cv | 95% CI |
|---|---|---|---|---|---|
| East Greenland | 2009 | August | 1429 | 0.45 | 616-3316 |
| Penny Strait-Lancaster Sound | 2009 | August | 2010 | 0.18 | 1416-2852 |
| Western Jones Sound | 2008 | August | 1415 | 0.18 | 997-2008 |
| Baffin Bay | 2009 | August | 1616 | 0.32 | 876-2980 |
| | 2009 | May | 2676 | 0.32 | 1140-4920 |
| West Greenland-SE Baffin Island (West Greenland only) | 2006 | March-April | 2791 | 0.54 | 1036-7522 |
| | 2008 | April | 3240 | 0.76 | 863-12170 |
| West Greenland-SE Baffin Island (SE Baffin Island only)[1)] | 2007 | September | 1056 | - | - |
| Svalbard | 2006 | August | 2629 | - | 2318-2998 |

1) Not corrected for walruses that were not present on land during the boat-count at terrestrial haulouts.

**Table 1:** Recent estimates of abundance (with coefficient of variation, CV, and 95% confidence intervals, CI) of various stocks of walruses in Greenland and neighbouring Canada and Svalbard. The estimates of abundance for the "East Greenland", "Baffin Bay" (both May and August 2009 estimates in combination) and "West Greenland only" (2006 and 2008) stocks were used in the assessment of walruses in Greenland waters.

The SC noted that there are no reliable data to provide information on abundance trends.

## ASSESSMENT BY STOCK

Recent abundance estimates, historical catches and an age- and sex-structured population dynamic model with density regulation were used to perform Bayesian assessments of the three stocks of Atlantic walrus that occur in Greenland. The estimates of status presented are comparable with an earlier model for the East Greenland population only. Owing primarily to updated abundance estimates, but also to an improved abundance prior, their estimates of current status have improved greatly for the West Greenland – S.E. Baffin Island and the Baffin Bay stocks since 2005.

### West Greenland – S.E. Baffin Island stock

The assessment estimated that the West Greenland – S.E. Baffin Island stock of walrus declined from a carrying capacity of 9,000 (90% CI:5,900-14,000) walruses in 1900 to an abundance of 3,200 (90% CI:1,790–5,430) individuals in 1960, after which time the population has been relatively stable with a local maximum of 4,500 (90% CI:3,650-5,550) walruses in 1993 and a lower 2010 abundance of 3,200 (90% CI:2,300-4,400).

This estimates a 2010 depletion ratio of 0.33 (90% CI:0.19-0.60) relative to the pre-exploitation level in 1900, and a yearly replacement of 130 (90% CI:61-190) individuals.

**Baffin Bay stock in the North Water polynya area**

The Baffin Bay stock is projected to have declined almost linearly from an estimated carrying capacity of 10,000 (90% CI:6,900-16,000) individuals in 1900, to an abundance of 2,100 (90% CI:1,500-3,100) walruses in 2010. The population is predicted to have a 2010 depletion ratio of 0.20 (90% CI:0.11-0.33) relative to pre-exploitation level in 1900 with a yearly replacement yield of 84 (90% CI:31-140). The estimate of current depletion for the Baffin Bay stock, however, is more uncertain than the estimates for the two other stocks owing to the great uncertainty about historical catches from this stock.

**East Greenland stock**

The assessment model for East Greenland walruses estimates a population that declined from a carrying capacity of 1,600 (90% CI:1,000-2,500) individuals in 1889 to a maximal depletion of 0.73 (90% CI:0.48-0.91) in 1909. Since this time the population is estimated to have increased slowly and steadily to a depletion ratio of 0.96 (90% CI:0.80-0.99) in 2010 with a corresponding abundance of 1,500 (90% CI:940-2,400) individuals. Given the low depletion, the current yearly replacement yield is also low [12 (90% CI:10-16)].

## SUSTAINABLE HARVEST LEVELS AND MANAGEMENT RECOMMENDATIONS

The SC has chosen to forward a range of options to allow managers to set the preferred balance between risk and removal levels of walruses.

**West Greenland – S.E. Baffin Island**

Table 2 shows the total annual removals that will allow the West Greenland – S.E. Baffin Island stock to increase with estimated probabilities from 50 to 95%, given a female fraction in the removals of either 68% or 20%. The SC recommends that future total removals be set for an assumed female fraction of 68%, given an acceptable protection level larger than or equal to 70% (numbers in bold). Advice based on a more male biased removal can only be given once it is proven that the actual removals are more male biased.

Total removals from the West Greenland – S.E. Baffin Island stock include catches and losses from Upernavik and south in West Greenland, and from Qikiqtarjuaq, Iqaluit and Pangnirtung in Canada.

| | W Greenland-SE Baffin Isl. | | Baffin Bay | | E Greenland |
|---|---|---|---|---|---|
| Probability | FF: 0.68 | FF: =0.20 | FF: 0.50 | FF: =.20 | FF: 0.10 |
| 0.50 | 108 | 154 | 83 | 108 | 26 |
| 0.60 | 100 | 141 | 75 | 98 | 23 |
| ***0.70*** | ***89*** | 129 | ***68*** | 87 | ***20*** |
| ***0.80*** | ***79*** | 115 | ***57*** | 74 | ***17*** |
| ***0.90*** | ***65*** | 95 | ***45*** | 58 | ***14*** |
| ***0.95*** | ***53*** | 80 | ***35*** | 45 | ***12*** |

**Table 2:** Estimated total removals that have a probability of 0.50 to 95% of being sustainable. (*FF = female fraction in the removals*).

**Baffin Bay stock**
Table 2 shows the total annual removals that will allow the Baffin Bay stock to increase with estimated probabilities from 50% to 95%, given a female fraction in the removals of either 50 or 20%. The SC recommends that future total removals be set for an assumed female fraction of 50%, given an acceptable protection level larger than or equal to 70% (numbers in bold). Advice based on a more male biased removal can only be given once it is proven that the actual removals are male biased.

Total removals from the Baffin Bay stock include catches and losses from the Qaanaaq area in West Greenland and Grise Fjord in Canada.

**East Greenland stock**
Table 2 shows the total annual removals in East Greenland that are smaller than or equal to 90% of the maximum sustainable yield with estimated probabilities from 50% to 95%, given a female fraction in the removals of 10%. The SC recommends that future total removals be set for an acceptable protection level larger than or equal to 70% (numbers in bold).

Total removals from the East Greenland stock include all catches and losses in East Greenland.

**General recommendations**
The **SC recommends** that:

- Total removals for all areas should be set under consideration of a probability of sustainability that is higher than or equal to 70%.
- Mechanisms for validating reporting of catch and loss both for Greenland and for Canada be designed and enforced.
- Managers consider establishing a more robust system for monitoring the sex and age composition of the catch (i.e. through collection of tissue samples from the catch).
- For the West, East Greenland and Baffin Bay stocks, the catches and losses (including the Canadian ones) and the future development of the population to

be monitored in light of total removals, as well as in light of climate change and planned industrial development.

- A common management regime be established between Greenland and Canada on shared stocks of walruses.

## EFFECTS OF HUMAN DISTURBANCE

Some effects of human disturbance on walruses are considered in a strategic environmental impact assessments (SEIA) prepared by the National Environmental Research Institute (Roskilde, Denmark) and the Greenland Institute of Natural Resources for three areas in Greenland (Central W Greenland: ca. 67°-71°N; eastern Baffin Bay or NW Greenland: ca. 71°-77°N and E Greenland: ca. 66°-81°N) as a part of the preparation to the licensing rounds for oil exploration. The major concerns in relation to walrus in Greenland are disturbance and accidental oil spills. The preliminary SEIA concluded that: (1) walruses in Central W Greenland are not likely to be impacted by exploration activities (only in summer and autumn) as there will be no temporal overlap between these activities and the presence of walruses in the area, while during development and production there is a risk of displacement from critical habitats. In the eastern Baffin Bay area the risk of temporal overlap of exploration activities and the occurrence of walrus is limited, while development and production activities potentially may pose a major risk for long-term population impacts. The situation in E Greenland is somewhat different as there will be a temporal overlap in the occurrence of walrus and both exploration and exploitation activities, and there will be a major risk of long-term population impacts.

The stock assessments above do not take into account the effect of the current level of human disturbance on the feeding grounds in West and Northwest Greenland. Current hunting levels in combination with boat traffic in general are likely to exclude walruses from fully exploring suitable feeding areas in West and Northwest Greenland. The overall effect on the West Greenland – S.E. Baffin Island and Baffin Bay populations will be difficult, if not impossible to quantify. However, should it be desirable to allow the two walrus populations a fair chance to re-establish haul out sites in West and Northwest Greenland over time, other management measures like protected areas are likely required in combination with restrictions on total allowable takes.

Owing to a lack of explicit studies, the SC is not in a strong position to provide advice on the effects of human disturbance on walrus.

## ADOPTION OF REPORT

The report was adopted at 20:00 on December 14 2009. The SC thanked the WG for making it possible to provide a solid management advice for walruses in Greenland for the first time ever.

Appendix 1

## LIST OF PARTICIPANTS

**Faroe Island**
Dorete Bloch
Geneviève Desportes
Bjarni Mikkelsen

**Greenland**
Aqqalu Rosing-Asvid
Fernando Ugarte
Lars Witting (Chairman)

**Iceland**
Gísli A. Víkingsson
Droplaug Olafsdottir

**Norway**
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**NAMMCO**
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