NAMMCO

SCIENTIFIC COMMITTEE

REPORT OF THE NINTH MEETING

***MS Nordkapp*, 9-12 October 2001**

North Atlantic Marine Mammal Commission
Polar Environmental Centre N-9296 Tromsø, Norway
Tel.: +47 77 75 01 80, Fax: +47 77 75 01 81 Email: nammco-sec@nammco.no, Web site: www.nammco.no

REPORT OF THE NINTH MEETING OF THE NAMMCO SCIENTIFIC COMMITTEE

MS Nordkapp, 9-12 October, 2001

Executive summary i
Report of the Ninth Meetion of the Scientific Committee 1

Appendix 1 List of participants 24
Appendix 2 Agenda 26
Appendix 3 List of documents...28

ANNEX 1 **Workshop Report: Marine mammals: From feeding behaviour or stomach contents to annual consumption – what are the main uncertainties?**...30

ANNEX 2 **Joint meeting of the Scientific Committee Working Group on the Population Status of Narwhal and Beluga in the North Atlantic and the Scientific Working Group of the Joint Commission on the Conservation and Management of Narwhal and Beluga**...51

ANNEX 3 **Report of the Scientific Committee Working Group on Abundance Estimates** 82

Scientific Committee Members 2001...103

REPORT OF THE NINTH MEETING OF THE NAMMCO SCIENTIFIC COMMITTEE

EXECUTIVE SUMMARY

The ninth meeting of the Scientific Committee of the North Atlantic Marine Mammal Commission was held 9-12 October on board the Norwegian coastal vessel *M/V Nordkapp*.

Feeding workshop

At its 8th meeting in Oslo, September 1998, the NAMMCO Council tasked the Scientific Committee with providing advice on the following:

i) to identify the most important sources of uncertainty and gaps in knowledge with respect to the economic evaluation of harvesting marine mammals in different areas;

ii) to advise on research required to fill such gaps, both in terms of refinement of ecological and economic models, and collection of basic biological and economic data required as inputs for the models,

iii) to discuss specific areas where the present state of knowledge may allow quantification of the economic aspects of marine mammal-fisheries interaction;

   a) what could be the economic consequences of a total stop in harp seal exploitation, versus different levels of continued sustainable harvest?

   b) what could be the economic consequences of different levels of sustainable harvest vs. no exploitation of minke whales?

The Working Group on the Economic Aspects of Marine Mammal - Fisheries Interactions met in February 2000 to consider parts i) and ii) of the request. One of the conclusions of the Working Group was that significant uncertainties remain in the calculation of consumption by marine mammals, and this uncertainty was the most important factor hindering the development of models linking consumption with fishery economics. Considering this conclusion, the Scientific Committee decided to convene a workshop, under the theme "Marine mammals: From feeding behaviour or stomach contents to annual consumption – what are the main uncertainties?", to further investigate the methodological and analytical problems in estimating consumption by marine mammals.

Two different approaches can in theory be used to estimate consumption by marine mammals: analyses of stomach contents in combination with estimates of stomach evacuation rates, and analyses of stomach or intestinal contents or faeces scaled to satisfy the estimated energy expenditure of the animals. Stomach evacuation methods are not generally applicable to most North Atlantic marine mammals, because evacuation rate must be determined experimentally under a wide variety of conditions, separately for each prey species and size, which is difficult for seals and dolphins and impossible for most whales. Such methods may only be applicable in areas and with species where a bolus-feeding pattern prevails, i.e. all food is eaten in one big meal per day, and this is not the case for many species in the northern North Atlantic.

Diet composition

The proportions of various prey items in the diet can be safely derived from undigested items in fresh stomach samples if such samples are available. Interpretation becomes increasingly more difficult as digestion proceeds. However, errors associated with identifying the prey eaten by seals from intestinal contents or faeces can be assessed using captive feeding experiments. A major difficulty for some species with the use of analyses of stomach or intestinal contents to determine diet composition is that samples are only easily available from a small part of the total distribution area of the animals and only from part of the year. Unfortunately sampling is all too often limited to the areas where samples can be collected easily.

Data obtained by the remote monitoring of marine mammals, using either data loggers or satellite-linked time-depth recorders, may be used to evaluate the diet composition of the tagged species The approach is based on comparing data on the temporal and spatial distribution of the predator, including its vertical movements (dive profiles), with related data for potential prey species, in order to identify matches that may indicate the likely prey species of the predator. The approach has obvious limitations, the most prominent ones being related to the often quite small sample size (due to the large costs associated with tagging), and the question of how to identify the likely prey in cases where more than one candidate exists. While the co-occurrence of predators and prey in time and space is highly indicative of predation, confirmatory observations by other means are always desirable.

Other methods of determining diet composition include analyses of fatty acids and stable isotopes (from biopsy samples). However these methods have not as yet proven capable of providing detailed (e.g. species composition) quantitative information on the diet of individual animals. They are therefore not in themselves adequate for use in estimating consumption.

Energy expenditure:
The energy expenditure (field metabolic rate) of free swimming whales can be determined from breathing rate and lung capacity measurements. While there are uncertainties with regard to the proportion of oxygen extracted from the air, and the amount of air that is breathed in, such estimates have proven useful for North Atlantic minke whales. Another factor that has to be taken into account is the amount of energy stored in tissues, such as blubber or growth of a foetus. This can be assessed by monitoring the seasonal changes in the amount of blubber and other tissues in whales, and generally requires lethal sampling. For North Atlantic minke whales, an additional 30% of daily energy expenditure may be deposited per day as tissue energy (fat and foetus) during the summer period.

There is a range of methods available for measuring the metabolic rate of seals in the field, but all have serious limitations. One potential method would be to use heart rate as an indicator of metabolic rate. With the use of satellite-linked tags, heart rate could be monitored remotely over time periods of multiple months. While there are potentially important limitations with this method, it appears currently to be the only candidate for development into a method for measuring the field metabolic rate of species such as harp and hooded seals throughout the year.

However, a main conclusion was that for all the relevant species of marine mammals in the North Atlantic the uncertainties in energy expenditure are small compared to the uncertainties in the estimates of abundance and compared to the uncertainties and lack of knowledge of the diet composition.

Research needs:
The following were identified by the Scientific Committee as the most important matters needing additional attention:

- Distribution of prey species in space and time;
- Spatial and temporal distribution of the diet composition of harp and hooded seals;
- Diet composition of dolphins (white-beaked, white-sided and bottlenose dolphins);
- Field metabolic rate of harp and hooded seals;
- Temporal changes in energy density of prey species;
- Spatial and temporal distribution of the diet composition of minke whales in the Northeast Atlantic, Icelandic waters and further west;
- Consumption estimates synthesised within a modelling framework including full uncertainty evaluation;

Future activities
The Scientific Committee reiterated its conclusion from 2000 that the estimation and model uncertainties are such that definitive answers to part iii) of the request from the Council, to quantify the economic aspects of marine mammal-fisheries interactions in candidate areas, cannot be expected in the near term. It was considered that the next step should be a workshop on ecosystem models aiming for a better understanding

of the ecological role of minke whales, and harp and hooded seals in the North Atlantic. A number of different models are available for such studies, and new modelling tools are being developed in many countries. In the workshop the properties of the different models should be discussed and compared, as well as the desired spatial and temporal resolution that should be used for the simulation runs. Important input data to the model calculations will include what prey species the marine mammals choose when more than one prey species is available (diet preferences). Lack of knowledge of important input data to the model calculations should also be identified.

Harp and hooded seals

The Scientific Committee considered the report of the Joint ICES/NAFO Working Group on Harp and Hooded Seals (ICES 2000), which had met at the ICES Headquarters in Copenhagen, Denmark, from 2 - 6 October 2000 to complete assessment work with harp seals in the White Sea/Barents Sea and hooded seals in the Greenland Sea, under terms of reference provided by the ICES Advisory Committee of Fisheries Management [ACFM]. The Scientific Committee concurred with the assessments and recommended catch options contained in the report.

Beluga and narwhal

The Scientific Committee Working Group on the Population Status of Narwhal and Beluga in the North Atlantic met jointly with the Scientific Working Group of the Joint Commission on the Conservation and Management of Narwhal and Beluga (JCNB), May 9-13 in Qeqertarsuaq, Greenland. Six hunters from Greenland participated in the first two days of the meeting, and two hunters from Canada participated in most of the meeting. They provided both written and oral contributions, and their contributions of traditional knowledge were considered in discussions of each relevant agenda topic.

West Greenland beluga

Catches

Landed catches in Canada between 1996 and 2000 averaged 38 beluga annually for communities hunting in the Baffin Bay and High Arctic areas. This is similar to catch levels over the past 25 years. Beluga are harvested in other parts of Canada but these animals are not believed to be part of the Baffin Bay-High Arctic population. Reported catches in West Greenland in the 1990s averaged 645 beluga landed annually. Unreported catches are thought to occur in at least some years in some localities in West Greenland, and these may be substantial. The reported landings do not include beluga killed-and-lost. New information on this source of death was reviewed at the meeting. The new information confirmed that killed-and-lost rates vary greatly with local conditions, and it will be hard to apply common correction factors to account for such mortality in assessments. However, the practice in recent assessments of taking each beluga reported in landings as representing 1.2 to 1.5 beluga killed by hunters was considered to still be the appropriate way to convert reported landings into total mortality due to hunting.

Surveys and abundance

In past years the accuracy of the West Greenland aerial surveys in 1981 and 1982 had been questioned. New analyses of those surveys confirmed that the estimates were not the results of an error in the analysis, and revised estimates were similar to those previously reported. Some hunters said that they thought beluga had changed their wintering distribution and possibly their fall migration path and timing. These concerns were discussed, and it was agreed that the expanded area surveyed in 1998 and 1999 would have covered the area used by beluga in winter as well as earlier surveys had, even if beluga had made some changes to their wintering distribution.

Ice entrapments

Hunters in West Greenland often take advantage of ice entrapments of beluga by harvesting the entrapped whales. While such harvests are accounted for in the catch data, the whales may have been fated to die in any case and therefore might be considered as natural mortality. When hunters take beluga that are trapped in ice, if these beluga are included in catch statistics, it is accounting for mortality of the same beluga twice. Several analyses were conducted with catch data including beluga that had been trapped in ice, and the same data with the entrapped beluga removed from the catch data. The effects on estimates of population size and on the response of beluga populations to management measures were very small. It was concluded that, where possible, ice entrapped whales should be excluded from the historic catch records when catches are used to estimate population size. However, it was also concluded that their inclusion or exclusion would have a very small effect on the calculations.

Assessments

Several different mathematical models for estimating how the population of beluga changed in West Greenland during the recent past, and predicting possible future stock sizes under various assumed management regimes, were reviewed. Regardless of which model was used in the calculations, results of the population modelling are quite similar. Beluga in the West Greenland area in winter are depleted to less than 25% of their abundance in 1950s, and more likely are 20% or less of their abundance 40-50 years ago. Landed catches in the 1990s are not sustainable, and are the reason for the continuing decline. The models all estimate a sustainable harvest of around 100, and certainly not more than 150 beluga killed annually at current population size.

There are many sources of uncertainty associated with these estimates, and different sources affect different models in slightly different ways. In general, however, uncertainties about the biology of beluga, such as their maximum potential rate of reproduction and maximum life expectancy, contribute relatively little to estimates of the current state of the stock and its recent rate of decline. On the other hand, uncertainties about the true landed catches, killed-and-lost rates, and the survey estimates, contribute much more to the uncertainty about the recent dynamics of the beluga population supporting the West Greenland hunt.

Specific management objectives for this beluga stock have not been set to guide in the choice of catch options. However, given its currently depleted state, on biological grounds it is desirable to halt the decline as quickly as possible, and to commence some rebuilding of the stock. Eight different harvesting plans were explored, ranging from immediate cessation of all hunting to continuation of harvesting at about the average catch of the 1990s. Most of the options, though, focused on moving to the current estimate of sustained removal (total of the number landed and killed-and-loss) of 100 beluga and maintaining catches there for the rest of the decade. These options simply differ in the speed with which the hunt is reduced to 100 beluga killed annually. Options that include keeping catch at 700 beluga annually beyond 2002 all result in further declines in the population. Continuing catches of 700 beluga/year nearly guarantees a continued decline for the coming decade, with a risk of 25% or greater that all beluga would be hunted out of West Greenland. However immediate reductions in catch to even 500 beluga, and subsequent reductions to 100 beluga annually over one to three more years all produce a halt to the decline and a low risk that the population in 2011 will be lower than the population in 2001. The more rapidly the total catch is reduced to 100 beluga, the greater the chance that the population will have increased by 2011, and be on a path to further increase.

There is great uncertainty in these predictions. Such uncertainty is unavoidable when predicting the future of biological populations. However, the uncertainty should not detract from the clear overall message that catches in the 1990s are not sustainable, and on biological grounds, conservation of the stock requires that catches be reduced. The greater and faster the reduction, the more likely it is that the population will stop declining and begin to rebuild. Moreover, if accurate and precise surveys are done at regular intervals over that period, the uncertainty in the present predictions will be reduced greatly. Subsequently, if management makes appropriate adjustments based on the future survey results, there can be even greater confidence that the stock is being kept on the path that is chosen by the managers.

Research Recommendations

- The highest priority is to conduct reliable surveys in West Greenland at regular intervals, with careful planning including local knowledge. The 2004 survey currently being planned would be an essential step.
- A series of focused discussions with hunters should be implemented, to review in greater detail their concerns about assumptions in the assessment models, and the values used for aspects of beluga biology, and to plan appropriate programs in response to their concerns.
- The re-analyses of the 1996 survey in the Canadian High Arctic should be completed, to evaluate whether or not the estimate of stock size is altered substantially from the estimate previously tabled.
- Co-operative programs with hunters, to improve the accuracy of reported landings and provide better data on killed-and-lost should be continued, and expanded to other communities where possible.
- Continue research on stock discrimination using contaminant and genetic study and satellite tagging.

Narwhal

Stock structure

Narwhal stock structure has been investigated using genetic analyses and contaminant levels in samples from diverse areas. The genetic analyses performed to date have not been helpful in resolving detailed differences and relationships among narwhal from different areas. The contaminants information did show that narwhal from different parts of the Baffin Bay might carry different contaminant concentrations, indicating that the populations are not completely mixed Hunters also reported that they are aware of different types of narwhal being present in some areas at different seasons. Satellite tagging of stocks summering in Canada shows extensive migrations in the western Baffin area, before over-wintering in central Davis Strait. These results suggest that some Canadian summering aggregations may be exposed to hunting in different areas during their annual migration route, but they do not seem likely to be contributing to catches in West Greenland. Correspondingly, the fall hunts in West Greenland are exploiting stock units summering elsewhere, possibly further north along the Greenland coast, where they are also hunted. In both cases, hunting mortality does not seem to be distributed evenly among all narwhal aggregations in the Baffin Bay area, with the possibility of some units being harvested several times and in different locations during a given year.

Catches

The average annual Canadian catch of narwhal from the Baffin Bay narwhal population (1996-2000) was about 364 narwhal. New data on narwhal killed-and-lost from a few communities has shown that these rates are highly variable, depending on local conditions and hunting methods. Some progress on improving the historic narwhal catch data from West Greenland back to 1962 has been made, although there are many unreliable periods in the catch record. These data will be important to future assessments. Although the data for 1980 to the present are not finalised, reported landings averaged 647 annually between 1993 and 1999. These landings do not include non-reported catches, which are thought to have been large in at least some years, or correction for narwhal killed-and-lost. Taken together, these catch data indicate catches have probably exceeded 1,000 narwhal annually for at least much of the 1990s.

Abundance

There are no recent reliable survey estimates for narwhal in either the Canadian High Arctic or West Greenland.

Assessments

It is not at present possible to assess the status of narwhal in the Baffin Bay area or adjacent areas. Further work is still required to produce the best possible recent catch history for the stock. Reliable surveys are also needed, in order to provide a population estimate for use in the analyses of effects of catches on the population. In the past, it was considered that if all narwhal in the Baffin Bay area comprised a single functional stock that was quite large, removals from this stock were low relative to the size of the stock. However, mortality due to hunting has increased, and when reasonable allowances are made for unreported catches and narwhal killed-and-lost, annual removals almost certainly exceed 1,000 narwhal. Moreover, the evidence for the existence of several stocks of narwhal in the area, rather than a single one, although not complete, is strong, and it is likely that some stock units are contributing to several hunts annually. Therefore there is a risk that at least some stock units may be over-harvested. There is also the concern that some of the largest catches, from West Greenland in the fall, are from stocks whose summering sites are unknown.

All these results argue strongly for a focused effort to assess these stocks as quickly as possible Surveys are already planned for summer 2001, to count narwhal in Inglefield Bredning and Melville Bay, two potentially large summering aggregations whose sizes are unknown. If these surveys are successful, it should be possible to conduct an analytical assessment of narwhal in West Greenland as early as 2002. Surveys of the Canadian summer aggregations should also proceed as quickly as possible. A high priority should be given to the development of a comprehensive plan for such a survey. Satellite tagging and contaminants work should also proceed on as wide a basis as feasible to help clarify stock structure and seasonal migration patterns.

Grey seals

The abundance of grey seals in Iceland has reportedly declined from an estimated 12,000 in 1992 to 6,000 in 1998. Hunting continues under a bounty system, with no quotas or other restrictions, and annual catch is about 500 animals. The Scientific Committee noted with concern the apparent population decline, continued harvesting and lack of monitoring of the Icelandic grey seal population, and cautioned that continued catches at this level may not be sustainable. Given that this species is taken in 3 NAMMCO member countries, the Scientific Committee considered it a good candidate for further assessment work, to extend and update the work carried out in 1996.

Other species

In addition to the above species the Scientific Committee reviewed progress regarding the following species: harbour porpoises, fin, minke and pilot whales, white-beaked and white-sided dolphins and harbour seals.

Status of analyses from NASS-95

At its 1999 meeting, the NAMMCO Council noted that abundance estimates from NASS-95 have not been completed for some species. The Council therefore recommended that the Scientific Committee complete abundance estimates for all species, as part of its efforts to monitor the abundance of all species in the North Atlantic. The Scientific Committee agreed to reactivate the Working Group on Abundance Estimates to prioritise and carry out further analyses from NASS-95. An additional task of the Working Group was to plan and co-ordinate the NASS-2001 survey.

Minke whales, Iceland

Aerial survey

The abundance estimate for minke whales from the Icelandic aerial survey formed a major part of the abundance estimate for Central North Atlantic minke whales used by the Scientific Committee in its assessments. New information has indicated that this estimate may have been positively biased because it was not corrected for errors in measuring angles of declinations. The Scientific Committee agreed that the NASS-95 aerial survey estimate was problematic. However the data may nevertheless be valuable for other purposes, such as comparison with other surveys in the area.

Shipboard survey

In 1997 the NAMMCO Scientific Committee Working Group on Abundance Estimates derived an estimate of the abundance of minke whales in the Icelandic shipboard survey area of NASS-95. However no documentation for this estimate exists. The estimate was therefore re-calculated from available data files, with results very similar to those previously reported.

Humpback whales, Iceland
An analysis of humpback whale abundance from the Icelandic component of the NASS-95 shipboard survey has been completed. A total of 252 sightings of 381 humpback whales were made by 2 vessels in the Icelandic survey area. A total abundance of 14,600 (95% CI 5,100-41,500) was estimated for the survey area using standard line transect methodology and stratification by geographic blocks. Abundance was greatest in the waters off the east coast of Iceland, with lesser numbers present off the west coast. This estimate is much higher than that from NASS-87 for roughly the same area and season, and the distribution of humpback whales was also different in 1995. The number of humpback whales seen per mile flown has increased over 4 aerial surveys conducted in 1986, 1987, 1995 and 2001 by an estimated 11% per year, indicating that the population around Iceland may have increased rapidly over that period. The Scientific Committee noted that the abundance estimate reported was much higher than previous estimates and not consistent with other estimates for the entire North Atlantic. The distribution of humpback whales was extremely clumped in the survey area and the survey itself was not optimised for humpbacks. The Scientific Committee therefore urged the completion of abundance estimates for this species from NASS-2001 as a high priority. The Committee also recommended that photo-ID and biopsy sampling should be carried out on humpbacks off East Iceland, for integration into the very extensive existing catalogues for the North Atlantic.

NASS-2001

Planning
Planning of the NASS-2001 survey was coordinated by the Working Group on Abundance Estimates, including target species, timing, coverage, survey platforms, survey methodologies and observer training. Target species of the survey were minke and fin whales for the Faroes and Iceland, and minke whales for Norway. For the first time the Faroese and Icelandic vessels would use identical methodology. The Norwegian survey methodology was somewhat different as the Norwegian component of the NASS survey was also a part of their national 6 year rotational survey program.

The Scientific Committee noted that this year the Norwegian and Faroese research vessels which had planned to conduct sighting surveys including waters around Great Britain were denied access to the Exclusive Economic Zone of the United Kingdom. This required survey plans to be changed at short notice and distorted the planned survey design. It also precluded the possibility of getting information on abundance and distribution of cetacean species within these waters. The Scientific Committee deplored this decision of the British authorities and emphasised its hope that in the future all nations in the region will give access to their waters for conducting surveys to enable complete coverage of the species' ranges.

Survey Reports

Faroe Islands

A total of about 2,500 nautical miles was covered on effort, and 459 groups of cetaceans comprising twelve species and 1798 individuals were sighted. The most common species was pilot whale, with 55 sightings of pilot whale groups, more than were sighted in the 1995 survey. .

Iceland

The ship survey was carried out by the 3 Icelandic vessels. The predetermined track lines were followed with some changes due to weather and ice conditions. A total of 1,674 sightings were made, comprising 14 species and 4,681 individuals. The most common large whale was the target species fin whale (516 sightings), followed by the humpback whale (415 sightings).

The Icelandic aerial survey was conducted over a period of about 3 weeks in July. Most of the planned tracklines were completed, but some areas could not be accessed due to poor weather conditions. A total of 537 sightings of 1,354 animals comprising at least 9 species were made, including 200 sightings of the target species minke whale. Humpback whales were by far the most common large whale sighted (161 sightings), while 118 sightings of dolphin groups were made.

Norway
As the Norwegian vessel which was planned to cover the North Sea block was denied access to the British EEZ, a last minute reallocation to the central Norwegian Sea was made. In the first part of the survey period about 570 nautical miles were covered on transect and 99 sightings were made, mostly of minke, fin and sperm whales. The second part of the survey was hampered by bad weather conditions and virtually no primary search effort was conducted. The other Norwegian vessel surveyed as planned in the SE Barents Sea.

Data analysis
Data analysis will be coordinated by the Working Group on Abundance estimates, which will meet early in 2002 to evaluate abundance estimates for the target species. The Working Group will also be tasked with undertaking a full evaluation of the platforms, equipment, methods and protocols used in NASS-2001, as this will be extremely useful in planning future NASS surveys, and with considering the publication of the results of this and other NASS surveys.

Science Fund
At their 8th meeting, at the request of the Council, the Scientific Committee approved a proposal for the establishment of a funding program to support scientific research of relevance to the Council and the Committee. In response to this proposal, the Council noted that while the proposed Science Fund was interesting and had potential, more time and discussion would be needed to reach a decision on the matter. The Council agreed to keep the matter under consideration and revisit it at the next meeting. The Scientific Committee reiterated their support for the idea of a NAMMCO Science Fund under their auspices. To further the proposal, the Committee decided to put forth examples of projects that would address issues put to it by Council, and could be supported within the proposed funding level of the Science Fund. These included projects on the ecology and biology of dolphin species, fin whale stock structure, ecology of harp and hooded seals in the Nordic Seas and status of grey seal populations in Nordic Seas.

Publications
In addition to Volume 1, *Ringed seals in the North Atlantic*, and Volume 2, *Minke whales, harp and hooded seals: Major predators in the North Atlantic ecosystem*, the following volumes of NAMMCO Scientific Publications are presently in progress (publication date in brackets):

i. *Sealworms in the North Atlantic: Ecology and population dynamics* (Dec. 2001)
ii. *Harbour Porpoises in the North Atlantic* (May 2002)
iii. *Population Status of Narwhal and Beluga in the North Atlantic* (Dec. 2002)

Next Meeting
It was decided that Iceland will host the next meeting of the Scientific Committee in September 2002, at a location yet to be determined.

REPORT OF THE NINTH MEETING OF THE NAMMCO SCIENTIFIC COMMITTEE

1. CHAIRMAN'S WELCOME AND OPENING REMARKS

Chairman Gísli Víkingsson welcomed the members of the Scientific Committee to their 9th meeting (Appendix 1), held aboard the Norwegian coastal steamer *MS Nordkapp.* He noted the presence of a new member from the Faroe Islands, Bjarni Mikkelsen. Members Mads Peter Heide-Jørgensen and Aqqalu Rosing-Asvid could not attend the meeting.

2. ADOPTION OF AGENDA

The Draft Agenda was accepted with minor changes (Appendix 2).

3. APPOINTMENT OF RAPPORTEUR

Daniel Pike, Scientific Secretary of NAMMCO, was appointed as Rapporteur.

4. REVIEW OF AVAILABLE DOCUMENTS AND REPORTS

4.1 National Progress Reports

National Progress Reports for 2000 from the Faroes, Iceland, and Norway were presented to the Committee. The National Progress Report from Greenland was not available.

4.2 Working Group Reports

Working Group Reports and other documents available to the meeting are listed in Appendix 3.

5. COOPERATION WITH OTHER ORGANISATIONS

5.1. IWC

Since the last annual meeting of the NAMMCO Scientific Committee, 2 annual meetings have been held in the IWC Scientific Committee. Of particular interest at the meeting in Adelaide in June 2000 were discussions on how to analyse and combine multiyear data for sightings surveys, progress of POLLUTION 2000+ and discussion of the Greenlandic research program. Multiyear analyses are of great relevance to the development of a new minke whale abundance estimate for the Northeast Atlantic based on survey data collected over the period 1996-2001. General principles were agreed although implementation has to be done on a case by case basis. POLLUTION 2000+, a program to study pollutant cause-effect relationships in cetaceans, has had problems obtaining sufficient funding. Nevertheless there was some progress in planning, and protocols for sampling have been agreed. The Greenland research program was discussed and a biopsy feasibility study for abundance estimation of minke and fin whales was encouraged as a first step.

A number of relevant issues were discussed at the IWC Scientific Committee meeting in London July 2001. The Catch Limit Algorithm (*CLA*) program written by the Norwegian Computing Centre was included in the Secretariat suite of programs after an accurate tuning parameter had been estimated. Among the few tasks remaining is to adjust convergence criteria to be robust when less precise integration is used in the algorithm.

Next year an implementation review of North Atlantic minke whales will be conducted, and a time schedule was set up for this work under an intersessional working group. Testing and development of abundance estimators in general are continuing.

Bycatch estimation methods were discussed extensively and an intersessional group was established to define the specific objectives for a questionnaire survey covering known or suspected whale bycatch fisheries. Further, bycatch estimates based on observer programs, genetic data and other methods were discussed. Other forms of human induced mortality, such as ship strikes, were also discussed.

With regards to the work with aboriginal whaling management procedures, little progress had been made in defining Strike Limit Algorithms for the Greenlandic hunt of minke and fin whales. Lack of information on stock structure, range and movement as well as abundance and trends hamper this development. Planning is proceeding for annual inshore surveys to at least get an index of relative abundance. Satellite tagging should continue and the information thus gained on distributional areas should be used in planning a large scale survey within five years time. So far the Scientific Committee has never been able to provide scientific advice on Greenland stocks of minke and fin whales due to the lack of data, and this is a matter of concern.

As preparation for a comprehensive assessment of North Atlantic humpback whales, an intersessional workshop was held to summarise the work under the Years of the North Atlantic Humpback (YoNAH) project, which included a substantial review of catch history, development of an assessment model and an analysis of genetic material. The assessment model was not able to reconcile all pieces of information, including catches, abundance estimates, mixing rates, and observed rates of increase. Consequently, the Scientific Committee was not able to fulfil the Comprehensive Assessment this year. The model needs to be reparameterised, further investigation into catch statistics must be done, and further analyses are needed, especially to elucidate stock structure.

Due to a lack of sufficient funding, the POLLUTION 2000+ project for the time being is restricted to projects on bottlenose dolphins and harbour porpoise.

The Scientific Committee has been asked to work with competition between cetaceans and fisheries, and recommended that a workshop, to focus on the question, ‘How are changes in abundance of cetaceans likely to be linked (in the short term and the long term) to changes in fishery catches?’ be arranged some time before the next annual meeting.

5.2 ICES

Haug reported from the ICES Annual Science Conference (ASC) 2000 held in Oslo. It was decided to merge two marine mammal working groups (Working Group on Marine Mammal Habitats and Working Group on Marine Mammal Population Dynamics and Trophic Interactions) into one new group: The ICES Working Group on Marine Mammal Population Dynamics and Habitats (WGMMPH). This new group met in the ICES headquarters in Copenhagen, Denmark, in April 2001 and addressed questions concerning the status and ecology of marine mammals in the North Sea. Furthermore, the group discussed questions concerning the impact of fisheries on marine mammals, marine mammals and contaminants, marine mammal diets, and abundance estimation of coastal (grey and harbour) seals. The WGMMPH reported the results of its deliberations to the Marine Habitat Committee at the ASC in 2001.

The other ICES committee that deals with marine mammal issues is the Living Resource Committee (LRC). In the new action plan for this committee, developed at the 2001 ASC, marine mammals are a natural integrated part. Thus, both present and future LRC theme sessions at the ASC are designed with marine mammals included. One example is a theme session at the 2001 ASC (Session J: The Life History, Dynamics, and Exploitation of Living Marine Resources: Advances in Knowledge and Methodology) where four marine mammal papers were presented. Suggested future theme sessions under the LRC with relevance to marine mammals include titles such as: ”Environmental Influences on Trophic Interactions”, ”Biological Effects of Contaminants in Marine Pelagic Ecosystems” and ”Monitoring techniques and estimating abundance of seals”.

5.3 Canada/Greenland Joint Commission on Conservation and Management of Narwhal and Beluga (JCNB)

In 2000 the Scientific Committee advised that the beluga stock that winters off West Greenland is substantially depleted and that present harvests are several times the sustainable yield, and, if continued, will likely lead to stock extinction within 20 years. The Scientific Committee provided a number of harvest options for the stock, which required substantial reductions in take to have a significant chance of stopping the stock decline. At their meeting in 2000, the Council of NAMMCO expressed concern about this matter but recognised that the JCNB had primary management authority for this stock, which is shared between Canada and Greenland. It was therefore proposed that the NAMMCO Scientific Committee Working Group on the Population Status of Narwhal and Beluga in the North Atlantic and the JCNB Scientific Working Group should meet jointly to provide further advice about this stock and narwhal stocks in the area. A joint meeting was held in May in Qeqertarsuaq, Greenland (see 8.4 and 8.5).

Subsequent to this meeting the Commission of the JCNB met in Iqaluit, Canada, and Daniel Pike attended as an Observer for NAMMCO. Pike reported that the JCNB had reflected the findings of the Joint Scientific Working Group in their advice to member countries, that the West Greenland Beluga were declining and that substantial harvest reductions were required. The JCNB had also provided prioritised research recommendations for both beluga and narwhal. The working relationship at the scientific level was seen as beneficial and the JCNB wished to continue this with further joint meetings.

Pike also reported that the Greenlandic authorities are introducing legislation designed to limit the take of beluga through the introduction of a quota system.

6. UPDATE ON STATUS OF MARINE MAMMALS IN THE NORTH ATLANTIC

At its 8th meeting in 1998 the Council asked the Scientific Committee to develop a strategy for how to incorporate the knowledge of users in the advice provided by the Scientific Committee. A strategy to utilise Stock Status Reports as a means to incorporate user knowledge was approved by the Scientific Committee at their 7th meeting. Under this system stock status reports would be developed by the Scientific Committee on stocks for which the Committee had provided advice. These documents would be used as the basis of discussion with user groups, and their input would be incorporated. The resulting documents would then reflect the best available scientific and user knowledge about the stock.

At its 9th meeting in 1999 the Council endorsed this proposal. Two stock status reports, on minke and pilot whales, have since been completed, but the process of integrating user knowledge has not begun as yet. In 2000 the Scientific Committee directed the Scientific Secretary to complete reports on ringed seal and walrus as the next highest priorities. Pike reported that the ringed seal document was nearly complete, but that due to competing priorities no further progress had been made. In addition, NAMMCO will be holding a conference in 2002 on integrating scientific and user knowledge in management decisions, so the process developed by the Scientific Committee may be superseded. However the stock status reports will still be valuable as plain-language summaries of the current scientific knowledge on these species that are accessible to the public through the NAMMCO web site and other means of publication. The Scientific Committee therefore directed the Scientific Secretary to complete reports on ringed seal and walrus as soon as possible, and continue work on other priority species.

7. ROLE OF MARINE MAMMALS IN THE MARINE ECOSYSTEM

7.1 Marine mammal feeding workshop

At its 8th meeting in Oslo, September 1998, the NAMMCO Council tasked the Scientific Committee with providing advice on the following:

i) to identify the most important sources of uncertainty and gaps in knowledge with respect to the economic evaluation of harvesting marine mammals in different areas;
ii) to advise on research required to fill such gaps, both in terms of refinement of ecological and economic models, and collection of basic biological and economic data required as inputs for the models,
iii) to discuss specific areas where the present state of knowledge may allow quantification of the economic aspects of marine mammal-fisheries interaction;
    a) what could be the economic consequences of a total stop in harp seal exploitation, versus different levels of continued sustainable harvest?
    b) what could be the economic consequences of different levels of sustainable harvest vs. no exploitation of minke whales?

The Working Group on the Economic Aspects of Marine Mammal - Fisheries Interactions met in February 2000 to consider parts i) and ii) of the request. One of the conclusions of the Working Group was that significant uncertainties remain in the calculation of consumption by marine mammals, and this uncertainty was the most important factor hindering the development of models linking consumption with fishery economics (NAMMCO 2001a). Considering this conclusion, the Scientific Committee decided to convene this workshop, under the theme "Marine mammals: From feeding behaviour or stomach contents to annual consumption – what are the main uncertainties?", to further investigate the methodological and analytical problems in estimating consumption by marine mammals.

The main task of the workshop was to consider the methodological approaches to the calculation of consumption by marine mammals, making a detailed assessment of their relative merits. The overall goal was to make concrete recommendations on what approaches should be emphasised, and to make recommendations for further research in this area.

Two different approaches can in theory be used to give a quantitative description of marine mammal diets: analyses of stomach contents in combination with estimates of stomach evacuation rates, and analyses of stomach or intestinal contents or faeces scaled to satisfy the estimated energy expenditure of the animals. For the latter method indirect evidence of the main prey species may be obtained from studies of feeding behaviour, e.g. by satellite-linked time-depth recorders, if samples of stomachs are difficult to obtain.

The stomach evacuation method is widely used in fishery studies, e.g. to determine the consumption of capelin by cod. In considering the applicability of stomach evacuation methods to marine mammals, the Working Group noted that evacuation must be determined experimentally under a wide variety of conditions, separately for each prey species and size, and that this was difficult for seals and dolphins and impossible for most whales. Such methods may only be applicable in areas and with species where a bolus-feeding pattern prevails, i.e. all food is eaten in one big meal per day, and this is not the case for many species in the northern North Atlantic. The level of assumptions required and general lack of data about evacuation rate for most marine mammals render these methods unsuitable for the calculation of consumption by North Atlantic marine mammals.

For the second method the diet composition and the energy expenditure may be estimated independently of each other.

Diet composition

The Working Group concluded that the proportions of various prey items in the diet could be safely derived from undigested items in fresh stomach samples if such samples are available. Interpretation becomes increasingly more difficult as digestion proceeds. However, errors associated with identifying the prey eaten by seals from intestinal contents or faeces can be assessed using captive feeding experiments. Such captive feeding trials reveal which bones are most or least resistant to digestion. They also show the influence of fish size and total meal size on the likelihood of recovering bones of prey consumed. Identifying all hard parts to species increases the likelihood of identifying all prey consumed. This is particularly important for large prey species whose heads are not eaten.

A major difficulty for some species with the use of analyses of stomach or intestinal contents to determine diet composition is that samples are only easily available from a small part of the total distribution area of the animals and only from part of the year. Harp seals in the Barents Sea illustrate this point as samples have as a rule been restricted to the areas along the ice edge in the spring and early summer. In discussion the Working Group observed that this example demonstrated the need for the collection of samples from the entire distribution range of the animal and at every time of the year, as diet may change greatly with changes in the distribution of prey species. Unfortunately sampling is all too often limited to the areas where samples can be collected easily. However, telemetry will be useful in defining the amount of overlap between marine mammal and fish distributions, provided the distributions of relevant fish species are available.

Data obtained by the remote monitoring of marine mammals, using either data loggers or satellite-linked time-depth recorders, may be used to evaluate the diet composition of the tagged species The approach is based on comparing data on the temporal and spatial distribution of the predator, including its vertical movements (dive profiles), with related data for potential prey species, in order to identify matches that may indicate the likely prey species of the predator. This approach is of particular interest when studying species such as harp and hooded seals, which, due to their pelagic migratory and diving behaviour, are not readily accessible for traditional diet composition studies based on collections of stomach/intestinal/faecal samples. The approach has obvious limitations, the most prominent ones being related to the often quite small sample size (due to the large costs associated with tagging), and the question of how to identify the likely prey in cases where more than one candidate exists. It was also emphasised that the approach depends heavily on the spatial and temporal resolution and quality of the fisheries resource data, which in most cases is much coarser than is the case for the distribution and dive behaviour data that may be collected from the predator. In discussion the Working Group noted that while the co-occurrence of predators and prey in time and space is highly indicative of predation, confirmatory observations by other means are always desirable. Extension of this work will require closer collaboration between marine mammal and fishery scientists at both national and international levels.

The Working Group also discussed the possibilities of obtaining information on diet composition from analyses of fatty acids and stable isotopes (from biopsy samples). It agreed that these methods are effective in detecting qualitative changes in feeding over the year or life history of the animal. They are also useful for obtaining some information on diet from areas and time periods from which information from traditional methods is not obtainable. However these methods have not as yet proven capable of providing detailed (e.g. species composition) quantitative information on the diet of individual animals, and some members were of the view that there was little hope that they ever would. They are therefore not in themselves adequate for use in estimating consumption.

Energy expenditure:
The energy expenditure (field metabolic rate) of free swimming minke whales has been determined from records of respiratory rate and lung capacity measurements. The Working Group agreed that although there are uncertainties with regard to oxygen extraction and the tidal volume fraction of the measured lung capacities, this estimate provides a useful value for the field metabolic rate of minke whales. Minke whales are amenable to this methodology because they breathe only once during each surfacing, the breathing frequency seems constant over large areas, and, like other whales, the tidal volume does not vary with physical activity. In order to calculate the total energy consumption of minke whales staying in the Northeastern Atlantic during summer time, one factor that has to be taken into account is the amount of energy stored in tissues, such as blubber or growth of a foetus. The calculations suggest that, on average, an additional 30% of daily energy expenditure is deposited per day as tissue energy (fat and foetus) during the summer period.

There is a range of methods available for measuring the metabolic rate of seals in the field, but all have serious limitations. There was discussion of the use of heart rate as an indicator of metabolic rate since that could be measured over time periods of multiple months. While the Working Group recognised that there were potentially important limitations with this method, it appears currently to be the only candidate for development into a method for measuring the field metabolic rate of species such as harp and hooded seals throughout the year. One alternative method of obtaining information on the energy consumption of wild seals is to use information on the level of food intake of captive animals fed food with known energy density. A study in which three four-year-old harp seals were kept under controlled conditions for a year was reported. The harp seals displayed seasonal changes in appetite, activity levels and fattening which correlates with information from wild populations. Also food intake, expressed as percent of body mass, varied between 1.5 and 5% depending on the season. The energy consumption estimated corresponds to a field metabolic rate (FMR) of about 2.7 times basal metabolic rate. Under certain assumptions such estimates of energy consumption can be used to calculate total food consumption of wild harp seal populations. The Working Group considered that the determination of FMR in captive animals was a valuable approach, but that some means was needed to correlate these observations with free-ranging animals. It has been shown through satellite tag deployments that harp seals spend 80 to 90% of their time diving, an activity that is not reproducible under conditions of captivity.

However, a main conclusion was that for all the relevant species of marine mammals in the North Atlantic the uncertainties in energy expenditure are small compared to the uncertainties in the estimates of abundance and compared to the uncertainties and lack of knowledge of the diet composition.

Discussion

The Scientific Committee found Table 1 in the Workshop Report to be informative and useful. The Scientific Committee was concerned that the recommendations in Table 2 appeared to combine scientific and political applicability in some cases. The Committee did not agree with the implication of this Table that, for example, stomach content analysis was not a suitable methodology for grey seals because the animals are protected in some jurisdictions. Stomach and/or intestinal content analysis will always be superior to faecal analyses for the determination of diet, even though scat samples may be more readily accessible for some species. In principle all methods are applicable to all species, but the success rate would vary between species.

The Scientific Committee further noted that Table 2 of the Workshop Report appeared to recommend specific methods of determining diet for North Atlantic species in isolation from one another. However many of the methods could be used more advantageously in combination. For example, stomach content or intestinal analyses of digested prey may not identify prey that is only partially eaten, especially if the portion consumed contains no hard parts. In such a case a better approach would be to use stomach or intestinal analyses in combination with another method, such as fatty acid analysis, animal-mounted camera or direct observation of feeding activities. Also, it was emphasised that the coincidental occurrence of predator and prey in space in time, as determined by telemetry and fisheries resource surveys, was not in itself strong enough evidence of predation. Such a methodology will always require confirmatory evidence from another method, such as collection of stomach samples where the animals are feeding. Although these points are covered to some extent in the text of the Working Group report, readers may be mislead if they use the recommendations in Table 2 out of context with the rest of the report.

Research needs:

Previous recommendations to move beyond point estimates of consumption to address the range of uncertainties in these estimates are being pursued. It is important to take account of all sources of uncertainties in such computations, even if this requires subjective assessment of the range and probability distribution appropriate to factors which are poorly known.

The following were identified by the Scientific Committee as the most important matters needing additional attention:

- Distribution of prey species in space and time;
- Spatial and temporal distribution of the diet composition of harp and hooded seals;
- Diet composition of dolphins (white-beaked, white-sided and bottlenose dolphins);
- Field metabolic rate of harp and hooded seals;
- Temporal changes in energy density of prey species;
- Spatial and temporal distribution of the diet composition of minke whales in the Northeast Atlantic, Icelandic waters and further west;
- Consumption estimates synthesised within a modelling framework including full uncertainty evaluation;

Future activities

The Scientific Committee reiterated its conclusion from 2000 that the estimation and model uncertainties are such that definitive answers to part iii) of the request from the Council, to quantify the economic aspects of marine mammal-fisheries interactions in candidate areas, cannot be expected in the near term. It was considered that the next step should be a workshop on ecosystem models aiming for a better understanding of the ecological role of minke whales, and harp and hooded seals in the North Atlantic. A number of different models are available for such studies, and new modelling tools are being developed in many countries. In the workshop the properties of the different models should be discussed and compared, as well as the desired spatial and temporal resolution that should be used for the simulation runs. Important input data to the model calculations will include what prey species the marine mammals choose when more than one prey species is available (diet preferences). Lack of knowledge of important input data to the model calculations should also be identified.

It was noted that the IWC may be holding a workshop on a similar theme with regard to cetaceans early in 2002 (see 5.1). The Scientific Committee considered that it was important that their workshop not be duplicative, so the results of the IWC workshop should be taken into consideration before proceeding. It was also emphasised that sufficient preparation time for such a meeting will be required, in order that high quality working papers can be prepared.

7.2 Other matters

Grey seal diet

Working paper SC/9/20 dealt with the feeding ecology of grey seals in North Norwegian waters. Both because the resident grey seals compete with local fisheries and interact with fish farming operations, and because they are final hosts for sealworms, a need to address questions concerning the feeding habits of the species in North Norway has emerged. The diet of grey seals has not been well known in Norwegian waters, and from North Norway it was previously completely undescribed. For these reasons, grey seal stomachs, intestines and faeces were collected from the western Finnmark and northern Nordland (Lofoten) counties in 1999 and 2000. The grey seals were found to be completely piscivorous in the area. Wolffish and gadoids, particularly cod, saithe and haddock, predominated in the samples. Both the wolffish and gadoids eaten were generally small (and young) specimens. Haug informed the Committee that the grey seal investigations will continue in 2002, and will also include studies of parasite infestations both in the seals and in certain fish species obtained close to the seal colonies.

Diet of harp and hooded seals

To enable an assessment of the ecological role of harp and hooded seals throughout their distributional range of the Nordic Seas (Iceland, Norwegian, Greenland Seas), a project was initiated in Norway in 1999. The project will pay special attention to the period July-February (i.e., between moulting and breeding), which is known to be the most intensive feeding period for both harp and hooded seals, and was started as a response to an initiative taken by the NAMMCO Scientific Committee. A first effort on this project occurred when seals were collected for scientific purposes on a multi-purpose expedition with R/V *Jan Mayen*, conducted in the pack ice belt along the east coast of Greenland during September-October 1999. A new, dedicated expedition, using the same vessel along the east Greenland pack ice edge, was conducted in July-August in 2000. Results described in working paper SC/9/21 from analyses of stomach and intestinal contents from captured seals revealed that the diets of both species were comprised of relatively few prey taxa. Pelagic amphipods of the genus *Parathemisto* (most probably almost exclusively *P. libellula*), the squid *Gonatus fabricii* and the polar cod *Boreogadus saida* were particularly important. These 3 prey items constituted 73% to 98% of the observed diet in hooded seals and 95% to 99% in harp seals in terms of calculated biomass. *G. fabricii* was the most important food item for both hooded and harp seals in September/October 1999, when intestine contents suggested that also polar cod was important for hooded seals, whereas *Parathemisto* was important for the harp seals. In July/August 2000, *Parathemisto* dominated the harp seal diet completely, whereas *G. fabricii* and polar cod constituted most of the hooded seal diet.

Haug reported that a new expedition with *Jan Mayen* was conducted in the pack ice belt east of Greenland (mainly in the Denmark Strait) in February/March 2001, and the collected material is being analysed. A final *Jan Mayen* cruise under the umbrella of this project is planned in the Greenland Sea in October 2002.

8. MARINE MAMMAL STOCKS -STATUS AND ADVICE TO THE COUNCIL

8.1 and 8.2 Harp and hooded seals

The Scientific Committee considered the report of the Joint ICES/NAFO Working Group on Harp and Hooded Seals [WGHARP] (ICES 2000), which had met at the ICES Headquarters in Copenhagen, Denmark, from 2 - 6 October 2000 to complete assessment work with harp seals in the White Sea/Barents Sea and hooded seals in the Greenland Sea, under terms of reference provided by the ICES Advisory Committee of Fisheries Management [ACFM].

Harp seals

Stock Identity, Distribution and Migration

Analysis of mitochondrial DNA from a small sample of animals collected in each of the four individual whelping areas (White Sea, Greenland Sea, Front and Gulf) confirm that the Northeast and Northwest Atlantic populations should be maintained as two different stocks. Samples from the White Sea and Greenland Sea could not be distinguished, but given the small sample size, it is unlikely that small differences would be identified. There are no reports of the exchange of mature adults between these two whelping areas which suggests that there is reproductive separation. Therefore, these two stocks should be managed separately unless further studies indicate otherwise. Analysis of a larger sample from the different whelping areas is necessary to determine further stock relationships. Cooperative work between Norway, Iceland and Canada using DNA sequence analysis and microsatellite analysis has been initiated to assess stock identity.

The Greenland Sea Stock

Recent catches

Only Norway took catches of harp seals in the Greenland Sea pack ice in 1999 and 2000. The total catches were 803 (including 608 pups) and 12,343 (6,328 pups) animals in 1999 and 2000, respectively. Parts of, or the whole quota, could be taken as weaned pups assuming 2 pups equalled one 1+ animal. Catches have remained significantly less than the quota since 1993.

Abundance

There are no estimates of the current pup production, so abundance estimates were based on tag-recapture experiments between 1983 and 1991. The model estimated a pup production of 76,700 (48,000 – 105,000) and 1+ population of 361,000 (210,000 – 629,000) for 2000.

Catch options
Sustainable catches were defined as the (fixed) annual catches that stabilise the future 1+ population. ACFM concluded that a catch of 15,000 1+ animals or an equivalent number of pups would be sustainable. If a harvest scenario including both 1+ animals and pups is chosen, one 1+ seal should be balanced by 2 pups.

The White Sea/ Barents Sea Stock
Recent catches
In 1999, the combined Russian and Norwegian catches were 36,000 animals, of which 35,023 were pups. This was below the given quota (21,400 1+ seals or 53,500 pups, where 2.5 pups equalled one 1+ animal). The 2000 combined catches were 44,770, of which 40,555 were pups. Again the total catch was below the allocated quota for 2000 (22,700 1+ seals or 56,750 pups).

Abundance
Airplane and helicopter surveys of White Sea harp seal pups were conducted by Russian scientists in March 1998 and twice in 2000 using traditional strip transect methodology and multiple sensors. The estimates are considered to be negatively biased since they were not corrected for pups which may be hidden from the camera or for pups missed by the readers. Furthermore, the survey estimates were not corrected for the temporal distributions of birth. Estimated pup production was 286,260 (CV .073) in 1998, 322,474 (CV .089) from the first survey in 2000 and 339,710 (CV .095) from the second survey in 2000.

There are reports that pup mortality rates may vary substantially in the White Sea region, and that in recent years these rates have been very high. Under the assumption that the pup mortality is five times the 1+ mortality, the model estimated a pup production of 314,000 (95% CI 283,000 – 346,000) and a 1+ population of 1,676,300 (95% CI 1,500,000 – 1,850,000) for 2000.

Catch options
Sustainable catches were defined as the (fixed) annual catches that stabilise the future 1+ population. Considering recent reports of possible high pup mortality rates, ACFM recommended an option that incorporated a high pup mortality (5 x 1+ mortality), i.e. a catch of 53,000 1+ animals or an equivalent number of pups would be sustainable. If a harvest scenario including both 1+ animals and pups is chosen, one 1+ seal should be balanced by 2.5 pups.

Hooded seals
The Greenland Sea Stock
Recent catches
Only Norway took catches of hooded seals in the Greenland Sea pack ice in 1999 and 2000. Total catches were 4,446 (including 3,525 pups) and 1,936 (1,346 pups) seals in 1999 and 2000 respectively. Parts of, or the whole quota, could be taken as weaned pups assuming 1.5 pups equalled one 1+ animal. Between 1990 and 2000 less than 30% of the quota was taken each year.

Abundance
Aerial surveys in 1997 resulted in estimates of pup production in the Greenland Sea of 23,762 pups (95% C.I. 14,819 to 32,705). This estimate is considered to be negatively biased since it was not corrected for the temporal distribution of births or for scattered pups Estimated pup production and 1+ population was 28,100 (16,000 – 40,000), and 102 000 (57,000 – 147,000), respectively, for 2000.

Catch options
Sustainable catches are defined as the (fixed) annual catches that stabilise the future 1+ population.

ACFM considered that a catch of 10,300 1+ animals or an equivalent number of pups would be sustainable. If a harvest scenario including both 1+ animals and pups is chosen, one 1+ seal should be balanced by 1.5 pups.

Indications of density dependence in harp seals?
Haug presented working paper SC/9/19, in which trends in mean age at sexual maturity (MAM) were analysed for the Greenland Sea and Barents Sea/White Sea stocks of harp seals, based on data series collected by Russian and Norwegian scientists from the early 1960s to the early 1990s. Together with historical data on length at age, values of MAM are used as indicators of *per capita* resource levels in the two stocks of Northeast Atlantic harp seals. There were no long term trends in the Greenland Sea data set: A common MAM of 5.6 years could be fitted to the data from 1959-1990, and there were no significant differences in length at age of moulting females between samples collected in 1964 and 1987. For Barents Sea / White Sea harp seals, MAM increased significantly from 5.4 years in the period 1962-1972 to 8.2 years in the period 1988-1993 concurrently with a decline in body growth rates found in earlier studies. The results indicate stock specific differences in *per capita* resource levels for maturing females, which might be related to different trends in stock abundance or density independent changes in habitat quality for the two stocks.

8.3. Harbour porpoise

8.3.1 Update on progress
Both Norway and Iceland will be introducing a requirement for mandatory reporting of marine mammal bycatch in fisheries, which should become operational in 2002.

Øien reported that feasibility studies into assessing the abundance of harbour porpoise in Norwegian inshore waters have been undertaken in 2000 and 2001. This involves combined line/strip transect cruises in nearshore waters.

8.4. Narwhal and beluga
8.4.1 Update on progress
The Scientific Committee Working Group on the Population Status of Narwhal and Beluga in the North Atlantic met jointly with the Scientific Working Group of the Joint Commission on the Conservation and Management of Narwhal and Beluga (JCNB), May 9-13 in Qeqertarsuaq, Greenland. Six hunters from Greenland participated in the first two days of the meeting, and two hunters from Canada participated in most of the meeting. They provided both written and oral contributions, and their contributions of traditional knowledge were considered in discussions of each relevant agenda topic.

West Greenland Beluga
With regard to beluga stock structure the group considered information on both genetic analyses and levels of contaminants in the blubber. The information supported past conclusions that there are several stocks of beluga in the Baffin Bay area, and clarified some of the relationships among beluga from different areas. According to genetic analyses, Grise Fiord and Greenland sample populations were very similar and both of these groups differ from Southeast Baffin and Lancaster Sound populations. Grise Fiord and Greenland samples differ in organochlorine contaminant signature. Hunters agreed that different beluga populations occurred throughout the area, and thought that in some places there would be beluga from different populations at different times of the year.

The debate about the accuracy of the methods used to determine the age of beluga was considered. An analysis concluded that regardless of the interpretation of the growth layers in beluga teeth, there would be relatively little change in the estimated maximum rate at which the beluga population could grow. Hunters said that they thought there were older beluga in some areas than were represented in the catch data of the scientists. It was concluded that there was no reason to change ageing current practices, and that the information on the ages of beluga in the catch would continue to be used in analyses of population status.

New information on catches of beluga in Canada and Greenland were presented. Landed catches in Canada between 1996 and 2000 averaged 38 beluga annually for communities hunting in the Baffin Bay and High Arctic areas. This is similar to catch levels over the past 25 years. Beluga are harvested in other parts of Canada but these animals are not believed to be part of the Baffin Bay-High Arctic population. Reported catches in West Greenland in the 1990s averaged 645 beluga landed annually. Unreported catches are thought to occur in at least some years in some localities in West Greenland, and these may be substantial. The reported landings do not include beluga killed-and-lost. New information on this source of death was reviewed at the meeting. The new information confirmed that killed-and-lost rates vary greatly with local conditions, and it will be hard to apply common correction factors to account for such mortality in assessments. However, the practice in recent assessments of taking each beluga reported in landings as representing 1.2 to 1.5 beluga killed by hunters was considered to still be the appropriate way to convert reported landings into total mortality due to hunting.

In past years the accuracy of the West Greenland aerial surveys in 1981 and 1982 had been questioned. New analyses of those surveys confirmed that the estimates were not the results of an error in the analysis. Revised estimates were similar to those previously reported. The early surveys may still not be completely comparable to the subsequent ones, because of the presence of larger pods in the 1980s and changes in survey equipment. The larger pods are thought to be easier to see than small pods, but harder to count accurately. Some hunters said that they thought beluga had changed their wintering distribution and possibly their fall migration path and timing. These concerns were discussed, and it was agreed that the expanded area surveyed in 1998 and 1999 would have covered the area used by beluga in winter as well as earlier surveys had, even if beluga had made some changes to their wintering distribution.

It was also noted that analyses of the survey of beluga in the Canadian High Arctic conducted in 1996 were being redone to provide better estimates of beluga abundance. The new analyses may change the estimate of 28,500 (95% CI = 13,900-58,200) beluga, reported in 1997, although the amount and direction of change in the estimate is not known at this time.

In response to a specific request from NAMMCO, the group considered the effect of taking account of ice entrapments on estimates of beluga populations and impacts of hunts on the populations. The concern here is that ice entrapments are accounted for in the assessments as a source of natural mortality. When hunters take beluga that are trapped in ice, if these beluga are included in catch statistics, it is accounting for mortality of the same beluga twice. Several analyses were conducted with catch data including beluga that had been trapped in ice, and the same data with the entrapped beluga removed from the catch data. The effects on estimates of population size and on the response of beluga populations to management measures were very small. It was concluded that, where possible, ice entrapped whales should be excluded from the historic catch records when catches are used to estimate population size. However, it was also concluded that their inclusion or exclusion would have a very small effect on the calculations. There was some discussion of how landings from ice entrapped beluga in future years should be treated in analyses. It was concluded that this would depend on the frequency of such entrapments, the numbers of beluga killed, and how those numbers of beluga compared to estimates of sustainable yield from the stocks.

The group reviewed several different mathematical models for estimating how the population of beluga changed in West Greenland during the recent past, and predicting possible future stock sizes under various assumed management regimes. The models differed in many assumptions about the reliability of survey data from various years and the biology of beluga; particularly the way that reproductive rate and life expectancy may changed when the abundance of beluga is near the highest that the environment can support. The models also differed in mathematical details regarding how past knowledge and uncertainties about data and biology are used. However, the models did use generally the same catch data (some models ran in 2001 used catch data with improvements not available in 2000), and very similar values for rates of biological processes like birth rate and age at which females first give birth.

Some of these values were discussed extensively with hunters, who expressed doubts about some of the values used, particularly the interval between calves for mature females. These issues should be pursed in more depth during further discussions with hunters and possibly additional research.

Regardless of which model was used in the calculations, results of the population modelling are quite similar. Beluga in the West Greenland area in winter are depleted to less than 25% of their abundance in 1950s, and more likely are 20% or less of their abundance 40-50 years ago. Landed catches in the 1990s are not sustainable, and are the reason for the continuing decline. The models all estimate a sustainable harvest of around 100, and certainly not more than 150 beluga killed annually at current population size. This number includes both beluga landed and killed-and-lost. These results are quite similar to results presented last year (NAMMCO 2001b) but the additional models that were considered allowed more alternative ideas about the survey data and beluga biology to be examined.

There are many sources of uncertainty associated with these estimates, and different sources affect different models in slightly different ways. In general, however, uncertainties about the biology of beluga, such as their maximum potential rate of reproduction and maximum life expectancy, contribute relatively little to estimates of the current state of the stock and its recent rate of decline. On the other hand, uncertainties about the true landed catches, killed-and-lost rates, and the survey estimates, contribute much more to the uncertainty about the recent dynamics of the beluga population supporting the West Greenland hunt.

Specific management objectives for this beluga stock have not been set to guide in the choice of catch options. However, given its currently depleted state, on biological grounds it is desirable to halt the decline as quickly as possible, and to commence some rebuilding of the stock. A series of scenarios were explored with one model, whose performance was similar to all the models explored and was not affected greatly by changes to key biological assumptions. The meeting considered eight different harvesting plans, ranging from immediate cessation of all hunting to continuation of harvesting at about the average catch of the 1990s (Annex 2, Table 1 and Fig. 2). Most of the options, though, focused on moving to the current estimate of sustained removal (total of the number landed and killed-and-loss) of 100 beluga and maintaining catches there for the rest of the decade. These options simply differ in the speed with which the hunt is reduced to 100 beluga killed annually. Some of these options were also presented to NAMMCO last year (NAMMCO 2001b), and others were investigated at the request of the Greenland Government during this meeting.

Options that include keeping catch at 700 beluga annually beyond 2002 all result in further declines in the population. Continuing catches of 700 beluga/year nearly guarantees a continued decline for the coming decade, with a risk of 25% or greater that all beluga would be hunted out of West Greenland. However immediate reductions in catch to even 500 beluga, and subsequent reductions to 100 beluga annually over one to three more years all produce a halt to the decline and a low risk that the population in 2011 will be lower than the population in 2001. The more rapidly the total catch is reduced to 100 beluga, the greater the chance that the population will have increased by 2011, and be on a path to further increase.

It is clear from the Fig. 2 (Annex 2) that there is high uncertainty in the predictions of the beluga stock size under various management strategies. Such uncertainty is unavoidable when predicting the future of biological populations. However, the uncertainty should not detract from the clear overall message that catches in the 1990s are not sustainable, and on biological grounds, conservation of the stock requires that catches be reduced. The greater and faster the reduction, the more likely it is that the population will stop declining and begin to rebuild. Moreover, if accurate and precise surveys are done at regular intervals over that period, the uncertainty in the present predictions will be reduced greatly. Subsequently, if management makes appropriate adjustments based on the future survey results, there can be even greater confidence that the stock is being kept on the path that is chosen by the managers.

Several areas for future research were identified:

- The highest priority is to conduct reliable surveys in West Greenland at regular intervals, with careful planning including local knowledge. The 2004 survey currently being planned would be an essential step.
- A series of focused discussions with hunters should be implemented, to review in greater detail their concerns about assumptions in the assessment models, and the values used for aspects of beluga biology, and to plan appropriate programs in response to their concerns.
- The re-analyses of the 1996 survey in the Canadian High Arctic should be completed, to evaluate whether or not the estimate of stock size is altered substantially from the estimate previously tabled.
- Co-operative programs with hunters, to improve the accuracy of reported landings and provide better data on killed-and-lost should be continued, and expanded to other communities where possible.
- Continue research on stock discrimination using contaminant and genetic study and satellite tagging.

Svalbard beluga
Lydersen reported that satellite telemetry experiments on Svalbard beluga had shown that the population seems to occupy the area year-round. Beluga in this area seldom leave coastal waters, and spend the majority of their time at glacier fronts. These areas are known to have a high abundance of potential prey for white whales, so foraging is the probable reason for this behaviour. Aerial surveys to assess the abundance of Svalbard beluga are under consideration.

Narwhal
Narwhal stock structure was investigated using genetic analyses and contaminant levels in samples from diverse areas. The genetic analyses found only two or three genetic types that dominated all samples. The genetic analyses performed to date were not helpful in resolving detailed differences and relationships among narwhal from different areas. The contaminants information did show that narwhal from different parts of the Baffin Bay might carry different contaminant concentrations, indicating that the populations are not completely mixed. More work is required to resolve population structure. Hunters also reported that they are aware of different types of narwhal being present in some areas at different seasons.

There was no new information presented on age composition or biological rates of narwhal. We continue to be unable to tell the true age of narwhal beyond the age of sexual maturity. Until we know more about the narwhal, it may be necessary to assume that they live, growth and reproduce much like beluga.

New catch data from Canada were presented. The average annual Canadian catch of narwhal from the Baffin Bay narwhal population (1996-2000) is about 364 narwhal. Catches from more southerly and westerly areas are thought to be from other stocks, resident in Canada and are not reported here. New data on narwhal killed-and-lost from a few communities were also presented. As with beluga, these rates are highly variable, depending on local conditions and hunting methods.

Progress on improving the historic narwhal catch data from West Greenland back to 1962 was also reported. This work is not complete, but it has revealed many unreliable periods in the catch record. The group agreed that efforts should focus on making the catch data from the last 10-20 years as complete and accurate as possible, because those data would be the ones that were important to assessments of current status. Although the data for 1980 to the present are not finalised, reported landings averaged 647 annually between 1993 and 1999. These landings do not include non-reported catches, which are thought to have been large in at least some years, based on maktak sales in areas with no reported landings. They also do not include any correction for narwhal killed-and-lost. Taken together, these catch data indicate catches have probably exceeded 1,000 narwhal annually for at least much of the 1990s.

The meeting reviewed what knowledge was available regarding the origin of narwhal that supported catches in different areas and seasons. Summer and early fall catches from many Canadian areas are supported by local summering aggregations, but even in that period, some Canadian catches are of migrating narwhal whose summer aggregations are uncertain. Large catches are taken in West Greenland from October through February and the origin of these narwhals is not known. Satellite tagging of stocks summering in Canada shows extensive migrations in the western Baffin area, before over-wintering in central Davis Strait. However no tagged narwhal from Canada migrated far enough east to be vulnerable to the fall hunts in West Greenland. Hunters also report that narwhal from Canadian waters do not contribute to catches in West Greenland. They also note that groups of narwhal with different appearances can be present in some areas at different seasons, and some of these groups travel widely within the Canadian coastal waters.

These results suggest that some Canadian summering aggregations may be exposed to hunting in different areas during their annual migration route, but they do not seem likely to be contributing to catches in West Greenland. Correspondingly, the fall hunts in West Greenland are exploiting stock units summering elsewhere, possibly further north along the Greenland coast, where they are also hunted. In both cases, hunting mortality does not seem to be distributed evenly among all narwhal aggregations in the Baffin Bay area, with the possibility of some units being harvested several times and in different locations during a given year. The available information has resulted in a preliminary map of what stock units may contribute to what hunts (Annex 2, Fig. 3). This hypothesis has many question marks. These must be resolved if reliable scientific advice is to be provided on narwhal.

There are no recent reliable survey estimates for narwhal in either the Canadian High Arctic or West Greenland. The previous estimate of the narwhal summer aggregation in Prince Regent Inlet and Peel Sound obtained from the 1996 Canadian High Arctic survey for beluga is also being recalculated, using an improved method of analysis. New information was presented on the diving pattern of narwhal. Using new instrumentation, it was possible to measure the proportion of time narwhal spent at depths where they could be seen by aerial surveys, and the proportion of time when they would be so deep that they would be unlikely to be seen. Such information is essential for converting survey counts of narwhal into population estimates. The results demonstrate that the proportion of time that narwhal would be too deep to be seen during aerial surveys varies with local conditions such as water depth, but the observed values were similar the value of 1.8 used in previous analyses.

It was not possible to assess the status of narwhal in the Baffin Bay area at this meeting or the impact of the hunt on the present population. Further work is still required to produce the best possible recent catch history for the stock. Reliable surveys are also needed, in order to provide a population estimate for use in the analyses of effects of catches on the population. In the past, it was considered that if all narwhal in the Baffin Bay area comprised a single functional stock that was quite large, removals from this stock were low relative to the size of the stock. However, new information seriously challenges this view. First, mortality due to hunting has increased, and when reasonable allowances are made for unreported catches and narwhal killed-and-lost, annual removals almost certainly exceed 1,000 narwhal. Moreover, the evidence for the existence of several stocks of narwhal in the area, rather than a single one, although not complete, is strong, and it is likely that some stock units are contributing to several hunts annually. Therefore there is a risk that at least some stock units may be over-harvested. There is also the concern that some of the largest catches, from West Greenland in the fall, are from stocks whose summering sites are unknown.

All these results argue strongly for a focused effort to assess these stocks as quickly as possible. It should be possible to complete improvements to catch data for both Canada and West Greenland within a year. Surveys are already planned for summer 2001, to count narwhal in Inglefield Bredning and Melville Bay, two potentially large summering aggregations whose sizes are unknown. If these surveys are successful, it should be possible to conduct an analytical assessment of narwhal in West Greenland as early as 2002.

Surveys of the Canadian summer aggregations should also proceed as quickly as possible. It may not be feasible to survey the entire area where narwhal may occur within a single year. However, a high priority should be given to the development of a comprehensive plan for such a survey. A team, including technical experts and knowledgeable local hunters, should be formed to develop the survey plan. Priority should be given to new surveys in areas known to support large abundance of narwhal, and areas where catches are concentrated. Satellite tagging and contaminants work should also proceed on as wide a basis as feasible to help clarify stock structure and seasonal migration patterns.

8.6 Fin whales

8.6.1 Update on progress

The NAMMCO Council has given high priority to research on the stock delineation of fin whales in the North Atlantic (NAMMCO 2000, 2001c). Bloch, Víkingsson and Witting reported on ongoing satellite tagging and biopsy collections in the Faroes, Iceland and Greenland. In 2000 in the Faroes, 8 tags were deployed but none transmitted. It is thought that the tags were destroyed when they were shot into the whales. In 2001, using a different deployment technique, 4 tags were deployed and 2 transmitted. One of these animals has moved into Spanish waters. In Iceland in 2001, 3 satellite tags were deployed, but none transmitted successfully. In addition, 16 biopsy samples have been collected in the Faroes, and these will be processed jointly with material from Iceland, Norway and the NW Atlantic. In Greenland one tag was deployed in 2000 and one in 2001, with the 2000 tag transmitting successfully for approximately 80 days showing movements between inshore and offshore areas of West Greenland.

Bloch notified the Committee on plans to secure funding for a larger scale, 6 year program of satellite tagging. While supporting these efforts, the Committee considered that it might be more efficient to work out the technical problems with the tagging of large whales before a large-scale program is undertaken. This could be done using a model species, such as killer or humpback whale, that could be tagged relatively easily and perhaps relocated after the tag had failed. An alternative approach would be to apply multiple tags to single animals. The Scientific Committee supported the development of such a research program and urged that it be undertaken.

In 2000 the Working Group on Fin Whales noted some discrepancies between catch data supplied by the IWC and that derived from Faroese archival sources, and recommended that these discrepancies be rectified as far as possible through archival research (NAMMCO 2001d). Bloch reported that this work was ongoing and that many of the important Faroese whaling records had been located. She also reported that a part of the old Norwegian catch records (1902-1916) from whaling stations in Iceland, Shetland and Ireland is placed in the National Archives (Rigsarkivet) in Copenhagen, Denmark.

The Scientific Committee noted with pleasure that much of the recommended work on fin whales was being undertaken, including new estimates of abundance (see 9.). However further assessments of Faroese and Icelandic stocks must await the results of these studies.

8.7 Minke whales

8.7.1 Update on progress

Øien reported that in 2001 Norway had completed one cycle of its 6-year cycle of sighting surveys. A new abundance estimate based on the past 6 years of survey will be developed under the guidance of an IWC Working Group in the coming year. Work continues on age determination of minke whales, and new methodologies are being evaluated. Three VHF tag deployments were carried out this year in order to obtain dive time series for use in abundance estimates. In addition, one satellite tag deployment was carried out, but the tag transmitted only 2 weeks.

Víkingsson reported that 2 satellite tag deployments had been carried out this year, one of which has lasted 6 weeks and is still transmitting.

8.8 White-beaked, white-sided dolphins and bottlenose dolphins

8.8.1 Update on progress

In 1999, the Council tasked the Scientific Committee with facilitating the previously requested assessment of these species, with an emphasis on the following:

- to analyse results from NASS 95 and other sightings surveys as a basis for establishing abundance estimates for the stocks;
- to coordinate the efforts of member countries to conduct research to fill the noted information gaps, taking advantage in particular of the sampling opportunities provided by the Faroese catch, as well as dedicated sampling in other areas.

In the Faroes, a sampling program has been initiated, and 44 samples have been collected so far from drive hunts. Stomach samples have also been collected and analysed in Iceland but this information has not yet been published. An application for a scientific take of *Lagenorhynchus* dolphins was rejected by the Norwegian authorities, but a program to obtain biopsy samples is ongoing.

It was noted that the average pod size of white beaked dolphins at sea, as estimated during the sighting surveys, is much smaller than the average size of pods landed in the Faroes. This is also the case for pilot whales (see 8.9). The reasons for this difference are not known.

8.9 Long-finned pilot whales

SC/9/22 and 23 reported on four successful satellite tag deployments carried out in the Faroe Islands in 2000. Positions were obtained for up to 47 days and the results show that the whales, which were tagged from the same drive, separated and went in different directions. Two of the tagged whales were after 10 days observed together in a pod, and 2 were found after 19 days as close as 2.3 km from each other. The whales showed a strong affinity for the deep water off continental shelves. Maximum dive depth was 828 m and maximum dive duration was 18 minutes. On average, the whales spent 60% of their time above 6m depth. More than 60% of the dives lasted less than 3 minutes. Compared to other odontocetes of similar size, pilot whales may have a lower dive capacity or utilise a niche in the water column that requires less diving activity.

The Scientific Committee was particularly interested to note that the large pod that was driven ashore apparently broke into smaller pods out at sea, some of which may later have re-combined. This is in accordance with observations from sightings surveys, which observe pod sizes on average much smaller than the average number landed in drive hunts. It may also be indicative of a dynamic social organization for this species. The Committee urged the continuation of this work.

8.10 Grey seals

Ólafsdóttir reported to the Committee that the abundance of this species in Iceland had declined from an estimated 12,000 in 1992 to 6,000 in 1998. Hunting continues under a bounty system, with no quotas or other restrictions, and annual catch is about 500 animals. The organisation that used to carry out monitoring of the population has ceased this activity, but continues to pay bounties.

The Scientific Committee noted with concern the apparent population decline, continued harvesting and lack of monitoring of the Icelandic grey seal population, and cautioned that continued catches at this level may not be sustainable.

In Norway harvest quotas are established on the basis of abundance estimates, with the objective of a sustainable harvest. No directed harvest occurs in the Faroes, but an unknown number of grey seals are shot by aquaculture operations. Given that this species is taken in 3 NAMMCO member countries, the Scientific Committee considered it a good candidate for further assessment work, to extend and update the work carried out in 1996 (NAMMCO 1997).

8.11 Other species

8.11.1 Harbour seals

Lydersen described an ongoing study of a small population of harbour seals in Svalbard. This is the most northerly population of this species in the world and is protected from hunting. A large proportion of the population has been live-captured, and various tissue and data have been collected for population dynamics, growth, diet pollution and physiological studies. In addition several tag deployments have been carried out. The population appears to be rather sedentary and localised. The average lifespan of the animals is lower than in other studied populations, but the reasons for this are not clear.

9. NORTH ATLANTIC SIGHTINGS SURVEYS

9.1 Status of analyses from NASS-95

9.1.1 Report of the Working Group on Abundance Estimates

At its 1999 meeting, the NAMMCO Council noted that abundance estimates from NASS-95 have not been completed for some species. The Council therefore recommended that the Scientific Committee complete abundance estimates for all species, as part of its efforts to monitor the abundance of all species in the North Atlantic. In 2000 the Scientific Committee reviewed the present status of analyses and publications from NASS-95, and agreed that further analyses of the abundance of non-target species (i.e. all but minke, pilot, fin and sei whales) from the NASS-95 survey should be conducted if they are warranted. The Scientific Committee agreed to reactivate the Working Group on Abundance Estimates to prioritise and carry out further analyses from NASS-95. An additional task of the Working Group was to plan and co-ordinate the NASS-2001 survey.

Icelandic aerial survey

The Working Group noted that the NAMMCO Scientific Committee had concluded that the NASS-95 aerial survey estimate (Borchers *et al.* MS 1997) was the best available estimate for this area (NAMMCO 1998a), and the estimate was later used in an assessment of the Central North Atlantic minke whale stock (NAMMCO 1999a). New information presented to the Working Group indicated that this estimate may have been positively biased because it was not corrected for errors in measuring angles of declinations. In general, observer error in distance estimation is a much more severe problem for surveys using cue counting than for those using line transect methods, and simple simulations indicated that positive bias of 100% or more can result if observation error is large. No duplicate sightings were available from the NASS-95 aerial survey, so bias due to observation error could not be evaluated. The Scientific Committee agreed that the NASS-95 aerial survey estimate was problematic. However the data may nevertheless be valuable for other purposes, such as comparison with other surveys in the area. Given that further analyses of these data were not likely to be profitable and that a new aerial survey estimate should be available from NASS-2001, the Scientific Committee considered that further analyses on these data should be of low priority.

Other analyses

Table 1 of the Working Group report presented a prioritised list of analyses to be carried out from NASS-95. While some of the tasks have been completed (see 9.1.2), most have not.

9.1.2 Work completed after Working Group meeting

9.1.2.1 Humpback whales, Iceland

Pike presented SC/9/8, an analysis of humpback whale abundance from the Icelandic component of the NASS-95 shipboard survey. A total of 252 sightings of 381 humpback whales were made by 2 vessels in the Icelandic survey area. Encounter rate varied greatly between survey blocks. Effective strip half-width (*esw*) was influenced by sea conditions, with *esw* being less at high Beaufort sea states. A total abundance of 14,600 (95% CI 5,100-41,500) was estimated for the survey area using standard line transect methodology and stratification by geographic blocks. Abundance was greatest in the waters off the east coast of Iceland, with lesser numbers present off the west coast. This estimate is much higher than that from NASS-87 for roughly the same area and season, and the distribution of humpback whales was also different in 1995.

SC/9/18 presented evidence from NASS aerial surveys that the stock of humpback whales off Iceland is growing. Mean encounter rate has increased over 4 aerial surveys conducted in 1986, 1987, 1995 and 2001 by an estimated 11% per year based on a log-linear regression. The reported rate of increase is in accordance with that reported by Sigurjonsson and Gunnlaugsson (1990) of 11.6% based on the recorded sightings by whalers operating west of Iceland.

The Scientific Committee noted that the abundance estimate reported in SC/9/8 is not in accordance with estimates from the YoNAH mark-recapture experiment (Smith *et al*. 1999), which indicate an abundance of 10,600 (95% CI 9,300-12,100) for the entire North Atlantic. The distribution of humpback whales was extremely clumped in the survey area and the survey itself was not optimised for humpbacks. However it was also noted that there are indications of increased range and sighting frequency of humpback whales from the NASS-2001 ship and aerial surveys, supporting the increasing trend described in SC/9/18. The Scientific Committee therefore urged the completion of abundance estimates for this species as a high priority. The Committee also recommended that photo-ID and biopsy sampling should be carried out on humpbacks off East Iceland, where sampling was limited in the YoNAH project, for integration into the very extensive existing catalogues for the North Atlantic.

9.1.2.2 Minke whales, Iceland

In 1997 the NAMMCO Scientific Committee Working Group on Abundance Estimates derived an estimate of the abundance of minke whales in the Icelandic survey area of NASS-95 (NAMMCO 1998b). This estimate had 2 components: one from coastal waters covered by the aerial survey, and the other from offshore waters covered by the shipboard survey. The shipboard estimate however was apparently calculated at the meeting, and no documentation for this estimate exists. NAMMCO (1998b) lists the abundance estimates and CV's from the shipboard survey by block (Table 2), but gives virtually no information on how these estimates were derived. In 2000 the Working Group on Abundance Estimates recommended that, as the Icelandic shipboard estimate forms part of the estimate for the Central Stock accepted by the NAMMCO Scientific Committee (NAMMCO 1999a), a document describing this analysis should be developed as a high priority. Working Paper SC/9/10 describes the re-calculation of this abundance estimate from surviving computer files. Although the estimate reported in NAMMCO (1998b) was not reproduced exactly, the re-calculated estimates are very close to those reported. A working paper describing the complete analysis will be completed in the near future.

The Scientific Committee commended this work and resolved that, in the future, all abundance estimates accepted by the committee should be documented and published in peer-reviewed journals as soon as feasible.

9.1.3 Recommendations for further work

The Scientific Committee considered that the best way to proceed with the further required analyses from NASS-95 would be to integrate them as far as possible with analyses of NASS-2001 data, described under item 9.2.3.

9.2 NASS-2001

9.2.1 Planning

9.2.1.1 Report of the Working Group on Abundance Estimates

The Working Group provided detailed plans for coordinating the sightings surveys of the 3 participating nations, including target species, timing, coverage, survey platforms, survey methodologies and observer training. Target species of the survey were minke and fin whales for the Faroes and Iceland, and minke whales for Norway. For the first time the Faroese and Icelandic vessels would use identical methodology, a Buckland/Turnock mode using 2 independent observer platforms. The Norwegian survey methodology was somewhat different as the Norwegian component of the NASS survey was also a part of their national 6 year rotational survey program.

9.2.1.2 Planning completed after Working Group meeting

Subsequent to the Working Group meeting, it was decided in Iceland to share survey platforms with a redfish survey being conducted in the southern and western parts of the survey area. This necessitated a change in the survey area,block structure and effort allocation.. The northern and eastern parts of the Icelandic area were still to be conducted by a dedicated survey vessel.

The Scientific Committee partially sponsored a cruise leader training meeting held in June in Copenhagen. At this meeting final preparations for the surveys were made. Survey methods and protocols were adapted to the target species and finalised. In addition training was conducted in survey methodology using the Buckland/Turnock ”tracker platform” mode. Cruise track design was finalised subsequent to the meeting with the assistance of Dr. David Borchers of the University of St. Andrews.

The Scientific Committee noted that this year the Norwegian and Faroese research vessels which had planned to conduct sighting surveys including waters around Great Britain were denied access to the Exclusive Economic Zone of the United Kingdom. This required survey plans to be changed at short notice and distorted the planned survey design. It also precluded the possibility of getting information on abundance and distribution of cetacean species within these waters. The Scientific Committee deplored this decision of the British authorities and emphasised its hope that in the future all nations in the region will give access to their waters for conducting surveys to enable complete coverage of the species' ranges.

9.2.2 Survey reports

9.2.2.1 Faroe Islands

Working paper SC/9/17 reported on the survey conducted by the Faroese vessel. Weather was reasonably good throughout the period, and the area was well covered except of course for the areas that were inaccessible due the British exclusion. A total of about 2,500 nautical miles was covered on effort, and 459 groups of cetaceans comprising twelve species and 1798 individuals were sighted. The most common species was pilot whale, with 55 sightings of pilot whale groups, more than were sighted in the 1995 survey. The methodology was considered useable but numerous recommendations for improvements were made.

9.2.2.2 Iceland

Working paper SC/9/16 reported on the survey carried out by the 3 Icelandic vessels. The predetermined track lines were followed with some changes due to weather and ice conditions. A total of 1,674 sightings were made, comprising 14 species and 4,681 individuals. The most common large whale was the target species fin whale (516 sightings), followed by the humpback whale (415 sightings).

The Icelandic aerial survey was presented in Working Paper SC/9/15. The survey was conducted over a period of about 3 weeks in July. Most of the planned tracklines were completed, but some areas could not be accessed due to poor weather conditions. For the first time the survey was completed in a full double platform mode. A total of 537 sightings of 1,354 animals comprising at least 9 species were made, including 200 sightings of the target species minke whale. Humpback whales were by far the most common large whale sighted (161 sightings), while 118 sightings of dolphin groups were made.

9.2.2.3 Norway

As the Norwegian vessel which was planned to cover the North Sea block was denied access to the British EEZ, a last minute reallocation to the central Norwegian Sea was made. In the first part of the survey period about 570 nautical miles were covered on transect and 99 sightings were made, mostly of minke, fin and sperm whales. Parts of the survey effort was made within the Icelandic survey area. The second part of the survey was hampered by bad weather conditions and virtually no primary search effort was conducted. The other Norwegian vessel surveyed as planned in the SE Barents Sea.

9.2.3 Data analysis

The Scientific Committee concurred that the estimation of abundance for the target species, minke and fin whales, should take highest priority. Analytical tasks were assigned to several members, with the goal of having the analyses prepared for the next meeting of the Working Group on Abundance Estimates (see 9.3).

9.3. Schedule and terms of reference for Working Group on Abundance Estimates

The Scientific Committee agreed that the Working Group on Abundance Estimates should meet in February 2002, by which time analyses of the abundance of the target and some other species should be completed. The Working Group will also be tasked with undertaking a full evaluation of the platforms, equipment, methods and protocols used in NASS-2001, as this will be extremely useful in planning future NASS surveys, and with considering the publication of the results of this and other NASS surveys (see 12.1).

10. NAMMCO SCIENCE FUND

At their 8th meeting the Scientific Committee approved a proposal for the establishment of a funding program to support scientific research of relevance to the Council and the Committee. This would facilitate closer cooperation between members intersessionally, and enable the Scientific Committee to play a more active role in addressing questions put to it by the Council. Projects could include the development of new assessment procedures, addressing key questions on stock delineation, multispecies interactions, or generally to address the priorities of both the Scientific Committee and the Council. The proposal subsequently presented to the Council at the 10th meeting in October 2000.

In response to this proposal, the Council noted that while the proposed Science Fund was interesting and had potential, more time and discussion would be needed to reach a decision on the matter. The Council agreed to keep the matter under consideration and revisit it at the next meeting.

The Scientific Committee reiterated their support for the idea of a NAMMCO Science Fund under their auspices. To further the proposal, the Committee decided to put forth examples of projects that would address issues put to it by Council, and could be supported within the proposed funding level of the Science Fund:

Ecology and biology of dolphin species (*Tursiops* and *Lagenorhynchus* spp.).

The Council has on several occasions (NAMMCO 1998c, 1999b, 2000, 2001c) requested advice on the distribution, abundance, ecological role and fisheries interactions of these speces. To enable the Scientific Committee to address these requests, it is suggested that studies be started to assess distribution, stock identity, reproduction, demography, feeding habits and ecological role of dolphin species (i.e. *Tursiops* and *Lagenorhynchus* spp.) in the North Atlantic.

Fin whale stock structure

The Council has requested assessments of fin whales around Iceland (NAMMCO 1999b) and the Faroe Islands (NAMMCO 2000). Full completion of these assessments requires further information on the stock structure of fin whales in the entire North Atlantic. The most productive means of conducting this research is likely through a large-scale satellite tracking (and biopsy sampling) project. The limited efforts made in 2000 and 2001 have already provided valuable new information on fin whale stock structure.

Ecology of harp and hooded seals in the Nordic Seas.

The Council has requested advice on the ecological role and fisheries interactions of North Atlantic marine mammals, particularly harp and hooded seals and minke whales (NAMMCO 1998c, 1999b, 2001c). To facilitate an assessment of the ecological role of harp and hooded seals throughout their distributional range of the Nordic Seas (Iceland, Norwegian, Greenland Seas) a project was planned by the Scientific Committee of NAMMCO in 1999, in which Norway was to undertake research cruises to the Greenland Sea at different times of the year, whereas Greenland, Iceland and the Faroes were to contribute with material obtained in bycatches and local hunts of the two species. However, it was not possible for Greenland, Iceland and the Faroes to fund their planned contributions to the project. It is suggested that such funding become available, and together with funding for a workshop to compile data and results and to initiate the production of scientific papers, possibly in a new volume of the NAMMCO Scientific Publications,

Status of grey seal (*Halichoerus grypus*) populations in Nordic Seas

To address previous requests from the Council (NAMMCO 1995), and the concern expressed by the Scientific Committee at this meeting on the Icelandic situation, an investigation on the status of grey seal stocks in Iceland, Faroe Islands and Norway and to evaluate effects of removals on each population is suggested. The project should include 1) abundance estimation 2) detailed recordings for catch statistics, 3) studies on biological parameters (e.g. age at maturity, fecundity, growth parameters), 4) stock delineations (population genetics, tagging, satellite tracking) and 5) feeding ecology.

11. DATA AND ADMINISTRATION

11.1 Revisions to Rules of Procedure for the Scientific Committee

The *Rules of Procedure for the NAMMCO Scientific Committee* were accepted by the Council at their second meeting in 1993. Since that time there have been changes both to the Scientific Committee and the Secretariat that necessitate some minor changes to the *Rules*. In addition, some points in the *Rules* required clarification or updating due to subsequent decisions of the Council. Pike presented a new draft of the *Rules* for the approval of the Scientific Committee. The revised *Rules* incorporate several minor changes, as well as a new draft *Guidelines for the Distribution of Scientific Committee Reports*.

The Scientific Committee approved the draft *Rules* and *Guidelines* as written. They will be presented to the Council for approval at the next meeting.

12. PUBLICATIONS

12.1 NAMMCO Scientific Publications

In addition to Volume 1, *Ringed seals in the North Atlantic*, and Volume 2, *Minke whales, harp and hooded seals: Major predators in the North Atlantic ecosystem*, the following volumes of NAMMCO Scientific Publications are presently in progress:

i. *Sealworms in the North Atlantic: Ecology and population dynamics*
   Co-editor Desportes informed the Committee that the proofs for this volume had been sent out for final review, and that publication could be expected late in 2001.

ii. *Harbour Porpoises in the North Atlantic:*
   Co-editor Tore Haug informed the Committee that 18 contributions are expected for this volume, which resulted from the International Symposium on North Atlantic Harbour. All papers have been reviewed and authors corrections made to some. It is expected that this volume will be ready for publication early in 2002.

iii. *Population Status of Narwhal and Beluga in the North Atlantic*

This volume, edited by Heide-Jørgensen and Øystein Wiig, will include about 16 papers. All papers have been reviewed, and authors corrections have been made on some. It is expected that this volume will be ready for publication in 2002.

The Scientific Committee noted that, although the previous plans for a volume on the results of the NASS surveys had been dropped, the completion of NASS-2001 would again make this a good candidate for a future volume. The volume could include previously unpublished results from NASS-95 and NASS-2001, as well as review papers integrating results from the entire series of NASS surveys. The Committee decided to direct the Working Group on Abundance Estimates to consider this at their next meeting.

13. BUDGET

The Scientific Secretary presented a draft budget for the Scientific Committee for 2001. He noted that the budget allocation of the Scientific Committee was utilised for the most part for funding invited experts to participate in Working Group meetings, and for contracted analyses. This year, a small surplus is anticipated.

The Scientific Committee, noting that some of the analyses of NASS-2001 data would require contracted work, directed the Scientific Secretary to apply any surplus to this activity. With that proviso, the Committee accepted the draft budget.

14. FUTURE WORK PLANS

14.1 Scientific Committee

It was decided that Iceland will host the next meeting of the Scientific Committee in September 2002, at a location yet to be determined.

14.2 Working groups

Working Group on the Economic Aspects of Marine Mammal-Fishery Interactions

See item 7.1. It is anticipated that this Group will hold a workshop in 2002.

Working Group on North Atlantic Fin Whales

The assessment of Faroese fin whales remains incomplete, pending the development of further information on stock delineation and abundance. The Working Group will meet again when this information becomes available, possibly in 2003.

Working Group on the Population Status of Narwhal and Beluga in the North Atlantic

This Working Group will meet when further information becomes available with which to complete assessments of narwhal stocks, likely not in 2002

Working Group on Abundance Estimates

See item 9.3. The Working Group will meet in February 2002.

Harbour Porpoise Symposium Steering Committee

This Committee will continue to act as the editorial board for the volume of NAMMCO Scientific Publications on North Atlantic harbour porpoises.

Other working groups may be activated or formed as needed to respond to requests for advice from the Council.

15. ANY OTHER BUSINESS

There was no other business.

16. ACCEPTANCE OF REPORT

The Report was accepted while pitching and rolling on the stormy Norwegian Sea, on October 12, 2001.

REFERENCES

Borchers, D.L., McCracken, M., Gunnlaugsson, Th., and Burt, M.L. (MS) 1997. Estimates of minke whale abundance from the 1987 and 1995 NASS aerial surveys. Working paper SC/5/AE/2 for the NAMMCO Scientific Committee Working Group on Abundance Estimates.

[ICES] International Council for the Exploration of the Sea. 2001. Report of the ICES/NAFO Working Group on Harp and Hooded Seals. ICES CM 2001/ACFM:08.

[NAMMCO] North Atlantic Marine Mammal Commission. 1995. Report of the fifth meeting of the Council. In: NAMMCO, *Annual Report 1995.* NAMMCO, Tromsø, 11-44.

[NAMMCO] North Atlantic Marine Mammal Commission. 1997. Report of the Scientific Committee *ad hoc* Working Group on Grey Seals. In: NAMMCO, *Annual Report 1996.* NAMMCO, Tromsø, 155-178.

[NAMMCO] North Atlantic Marine Mammal Commission. 1998a. Report of the Scientific Committee. In: NAMMCO, *Annual Report 1997.* NAMMCO, Tromsø, 85-124.

[NAMMCO] North Atlantic Marine Mammal Commission. 1998b. Report of the Scientific Committee Working Group on Abundance Estimates. In: NAMMCO, *Annual Report 1997.* NAMMCO, Tromsø, 173-202.

[NAMMCO] North Atlantic Marine Mammal Commission. 1998c. Report of the seventh meeting of the Council. In: NAMMCO, *Annual Report 1997.* NAMMCO, Tromsø, 9-60.

[NAMMCO] North Atlantic Marine Mammal Commission. 1999a. Report of the sixth meeting of the Scientific Committee. In: NAMMCO, *Annual Report 1998.* NAMMCO, Tromsø, 89-106.

[NAMMCO] North Atlantic Marine Mammal Commission. 1999b. Report of the eighth meeting of the Council. In: NAMMCO, *Annual Report 1998.* NAMMCO, Tromsø, 9-55.

[NAMMCO] North Atlantic Marine Mammal Commission. 2000. Report of the ninth meeting of the Council. In: NAMMCO, *Annual Report 1999.* NAMMCO, Tromsø, 11-49.

[NAMMCO] North Atlantic Marine Mammal Commission. 2001a. Report of the Working Group on the Economic Aspects of Marine Mammal-Fisheries Interactions. In: NAMMCO, *Annual Report 2000*, NAMMCO, Tromsø, 169-202.

[NAMMCO] North Atlantic Marine Mammal Commission. 2001b. Report of the Working Group on the Population Status of Narwhal and Beluga in the North Atlantic. In: NAMMCO, *Annual Report 2000*, NAMMCO, Tromsø, 252-273.

[NAMMCO] North Atlantic Marine Mammal Commission. 2001c. Report of the tenth meeting of the Council. In: NAMMCO, *Annual Report 2000*. NAMMCO, Tromsø, , 11-69.

[NAMMCO] North Atlantic Marine Mammal Commission. 2001d. Report of the Working Group on North Atlantic Fin Whales. In: NAMMCO, *Annual Report 2000*, NAMMCO, Tromsø, 274-294.

Sigurjónsson, J. and Gunnlaugsson, Th. 1990. Recent trends in abundance of blue (*Balaenoptera musculus*) and humpback whales (*Megaptera novaeangliae*) off west and southwest Iceland, with a note on occurrence of other cetacean species. *Rep. int. Whal. Commn* 40:537-551.

Smith, T.D., Allen, J., Clapham, P.J., Hammond, P.S., Katona, S., Larsen, F., Lien, J., Mattila, D., Palsbøll, P.J., Sigurjónsson, J., Stevick, P.T. and Øien, N. 1999. An ocean-basin-wide mark-recapture study of the North Atlantic humpback whale (*Megaptera novaengliae*). *Mar. Mam. Sci*. 15:1-32.

Appendix 1

NINTH MEETING OF THE SCIENTIFIC COMMITTEE

LIST OF PARTICIPANTS

Faroe Islands

Dorete Bloch
Museum of Natural History
Fútalág 40, FO-100 Tórshavn, Faroe Islands
Tel.: +298 318 588
Fax: +298 318 589
E-mail: doreteb@ngs.fo

Geneviève Desportes
Fjord and Belt Centre
Margrethes Plads 1
DK-5300 Kerteminde, Denmark
Tel.: +45 65 32 57 83
Fax: +45 65 32 42 64
E-mail: genevieve@fjord-baelt.dk

Bjarni Mikkelsen
Museum of Natural History
Fútalág 40, FO-100 Tórshavn, Faroe Islands
Tel.: +298 318 588
Fax: +298 318 589
E-mail: bjarnim@ngs.fo

Greenland

Lars Witting
Greenland Institute of Natural Resources
P.O.Box 570,
DK-3900 Nuuk, Greenland
Tel.: +299 32 10 95
Fax: +299 32 59 57
E-mail: larsw@natur.gl

Iceland

Þorvaldur Gunnlaugsson
Marine Research Institute,
PO Box 1390,
IS-121 Reykjavik, Iceland
Tel.: +354 5331363
Fax: +354 5623790
E-mail: thg@halo.is

Droplaug Ólafsdóttir
Marine Research Institute,
PO Box 1390,
IS-121 Reykjavik, Iceland
Tel: +354 5520 240
Fax: +354 5623 790
e-mail: droplaug@hafro.is

Gísli A. Víkingsson (Chairman)
Marine Research Institute
P.O. Box 1390
IS-121 Reykjavik, Iceland
Tel.: +354 55 20240
Fax: +354 5 623790
E-mail: gisli@hafro.is

Norway

Tore Haug
Norwegian Institute of
Fisheries and Aquaculture
N-9291 Tromsø, Norway
Tel.: +47 77 62 92 20
Fax: +47 77 62 91 00
E-mail: toreh@fiskforsk.norut.no

Nils Øien (Vice Chairman)
Institute of Marine Research
P.O.Box 1870 Nordnes,
N-5024 Bergen, Norway
Tel.: +47 55 23 86 11
Fax: +47 55 23 86 17
E-mail: nils@imr.no

Christian Lydersen
Norwegian Polar Institute
Polarmiljøsenteret
N-9296 Tromsø, Norway
Tel: +47 77 75 05 23
Fax: +47 77 75 05 01
E-mail: christia@npolar.no

Ex-Officio Members

Grete Hovelsrud-Broda,
General Secretary,
North Atlantic Marine Mammal Commission,
Polar Environmental Centre,
N-9296 Tromsø, Norway
Tel: +47 77 75 01 80
Fax: +47 77 75 01 81
E-mail: gretehb@nammco.no

Daniel Pike,
Scientific Secretary,
North Atlantic Marine Mammal Commission,
Polar Environmental Centre,
N-9296 Tromsø, Norway
Tel: +47 77 75 01 80
Fax: +47 77 75 01 81
E-mail: daniel.pike@nammco.no

Other

Charlotte Winsnes,
Administrative Co-ordinator,
North Atlantic Marine Mammal Commission,
Polar Environmental Centre,
N-9296 Tromsø, Norway
Tel: +47 77 75 01 80
Fax: +47 77 75 01 81
E-mail: nammco-sec@nammco.no

Appendix 2

AGENDA

1. Chairman's welcome and opening remarks
2. Adoption of Agenda
3. Appointment of Rapporteur
4. Review of available documents and reports
   4.1 National Progress Reports
   4.2 Working Group Reports
   4.3 Other reports and documents
5. Cooperation with other organisations
   5.1. IWC
   5.2 ICES
   5.3 Canada/Greenland Joint Commission on Conservation and Management of Narwhal and Beluga
6. Update on Status of Marine Mammals in the North Atlantic
7. Role of marine mammals in the marine ecosystem
   7.1 Marine mammal feeding workshop
   7.2 Other matters
9. Marine mammal stocks -status and advice to the Council
   8.1. Harp seals
      8.1.1 Update on progress
      8.1.2 Future work
   8.2. Hooded seals
      8.2.1 Update on progress
      8.2.2 Future work
   8.3. Harbour porpoise
      8.3.1 Update on progress
      8.3.2 Future work
   8.4. Narwhal
      8.4.1 Update on progress
      8.4.2 Future work
   8.5 Beluga
      8.5.1 Update on progress
      8.5.2 Future work
   8.6 Fin whales
      8.6.1 Update on progress
      8.6.2 Future work
   8.7 Minke whales
      8.7.1 Update on progress
      8.7.2 Future work
   8.8 White-beaked, white-sided dolphins and bottlenose dolphins
      8.8.1 Update on progress
      8.8.2 Future work
   8.9 Pilot whales
      8.9.1 Update on progress
      8.9.2 Future work
   8.10 Grey seals
      8.10.1 Update on progress
      8.10.2 Future work

8.11 Other species

9. North Atlantic Sightings Surveys
   9.1 Status of analyses from NASS-95
      9.1.1 Report of the Working Group on Abundance Estimates
      9.1.2 Work completed after Working Group meeting
         9.1.2.1 Humpback whales, Iceland
         9.1.2.2 Minke whales, Iceland
      9.1.3 Recommendations for further work
   9.2 NASS-2001
      9.2.1 Planning
         9.2.1.1 Report of the Working Group on Abundance Estimates
         9.2.1.2 Planning completed after Working Group meeting
      9.2.2 Survey reports
         9.2.2.1 Faroe Islands
         9.2.2.2 Iceland
         9.2.2.3 Norway
      9.2.3 Data analysis
         9.2.3.1 Faroes
         9.2.3.2 Iceland
         9.2.3.3 Norway
   9.3. Schedule and terms of reference for Working Group on Abundance Estimates
10. NAMMCO Science Fund
11. Data and administration
   11.1 Revisions to Rules of Procedure for the Scientific Committee
   11.2 Draft Guidelines for the Distribution of Scientific Committee Reports
12. Publications
   12.1 NAMMCO Scientific Publications
   12.2 Other publications
13. Budget
14. Future work plans
   14.1 Scientific Committee
   14.2 Working groups
   14.3 Other matters
15. Any other business
16. Acceptance of report

Appendix 3

LIST OF DOCUMENTS

	Title
SC/9/1	List of Participants
SC/9/2	Provisional Annotated Agenda (Draft)
SC/9/3	List of Documents
SC/9/NPR-F	National Progress Report – Faroe Islands
SC/9/NPR-I	National Progress Report – Iceland
SC/9/NPR-N	National Progress Report – Norway
SC/9/5	Workshop Report: Marine mammals: From feeding behaviour or stomach contents to annual consumption - What are the main uncertainties?
SC/9/6	Haug, T. Harp and hooded seals – recent management work in ICES
SC/9/7	Final Report of the joint meeting of the NAMMCO Scientific Working Group on the Population Status of Narwhal and Beluga in the North Atlantic and the Canada/Greenland Joint Commission on Conservation and Management of Narwhal and Beluga Scientific Working Group.
SC/9/8	Report of the NAMMCO Scientific Committee Working Group on Abundance Estimates.
SC/9/9	Pike, D.G., Gunnlaugsson, Th., and Víkingsson, G.A. Estimates of humpback whale (*Megaptera novaeangliae)* abundance in the North Atlantic, from NASS-95 shipboard survey data
SC/9/10	Pike, D.G., Gunnlaugsson, Th., and Víkingsson, G.A. A reanalysis of minke whale (*Balaenoptera acutorostrata*) abundance from Icelandic NASS-95 shipboard data.
SC/9/11	Status of the proposed NAMMCO Science Fund
SC/9/12	Revisions to the *Rules of Procedure for the Nammco Scientific Committee*
SC/9/13	NAMMCO Scientific Committee Budget 2001.
SC/9/14	Summary of requests by NAMMCO Council to the Scientific Committee, and responses by the Scientific Committee
SC/9/15	Pike, D.G., Gunnlaugsson, Th., Henningsson, U., Hauksson, E. and Thordarson, E. North Atlantic Sightings Survey 2001 (NASS-2001): Aerial survey in coastal Icelandic waters.

SC/9/16	Ólafsdóttir, D., Víkingsson, G.A., Gunlaugsson, Th. and Halldórsson, S.D. Survey report from the Icelandic shipboard survey of NASS-2001.
SC/9/17	Desportes, G., Mikkelsen, B., Bloch, D., Danielsen, J., Hansen, J and Mouritsen, R. Survey report from the Faroese shipboard survey of NASS-2001-10-04
SC/9/18	Gunnlaugsson, Th. and Víkingsson, G.. Trends in humpback whale (M*egaptera novaeangliae)* sightings rates from aerial surveys in Icelandic waters during 1987-2001
SC/9/19	Frie, A.K., Potelov, V., Kingsley, M. and Haug, T.. Trends in age at maturity and growth parameters of female Northeast Atlantic harp seals (*Pagophilus groenlandicus*).
SC/9/20	Nilssen, K.T., Haug, T., Corkeron, P. and Lindblom, C. On the diet of grey seals *Halichoerus grypus* in Lofoten and Finmark, North Norway.
SC/9/21	Haug, T., Nilssen, K.T. and Lindblom, L. Diet studies of harp and hooded sealsin drift ice waters along the east coast of Greenland in 1999 and 2000.
SC/9/22	Bloch, D., Heide-Jørgensen, M.P., Stefansson, E., Mikkelsen, B., Ofstad, L.H., Dietz, R. and Andersen, L.W. Short-term movements of pilot whales *Globicephala melas* around the Faroe Islands.
SC/9/23	Heide-Jørgensen, M.P., Bloch, D., Mikkelsen, B., Stefansson, E., Ofstad, L.H. and Dietz, R. Diving behaviour of pilot whales around the Faroe Islands.

Annex 1

MARINE MAMMALS: FROM FEEDING BEHAVIOUR OR STOMACH CONTENTS TO ANNUAL CONSUMPTION – WHAT ARE THE MAIN UNCERTAINTIES?

Tromsø, 26-28 September, 2001

1. OPENING REMARKS

Chairman Lars Walløe welcomed the members (Appendix 1) to the Workshop, and asked Grete Hovelsrud-Broda, General Secretary of NAMMCO, to give the background to the activities of NAMMCO in this area.

A 1996 Working Group (NAMMCO 1998) looked at the feeding ecology of minke whales, harp and hooded seals and found that there were many uncertainties involved estimating consumption by these species. It also considered the use of multispecies models to assess species interactions in the Barents Sea and Central North Atlantic. The Scientific Committee, based on the results from the Working Group, concluded that minke whales, harp seals and hooded seals in the North Atlantic might have substantial direct and/or indirect effects on commercial fish stocks.

In 1997, the Council requested the Scientific Committee to pay special attention to studies related to competition and the economic aspects of marine mammal- fisheries interactions. The Scientific Committee, in response, convened a Working Group on the Economic Aspects of Marine Mammal - Fisheries Interactions (NAMMCO 1999). This Working Group considered bio-economic models of varying complexity and associated ecosystem models, and concluded that "many of the analyses were in a preliminary stage and should only be taken as first indications”. They further concluded that, despite the preliminary nature of the results, the emerging cost benefit figures warranted serious consideration, as the overall costs to the fishing, whaling and sealing industries incurred by not whaling and/or not sealing could be quite considerable, and that the effects due to predation could be an important part of the overall picture.

At its 8th meeting in Oslo, September 1998, the NAMMCO Council tasked the Scientific Committee with providing advice on the following:

i) to identify the most important sources of uncertainty and gaps in knowledge with respect to the economic evaluation of harvesting marine mammals in different areas;
ii) to advise on research required to fill such gaps, both in terms of refinement of ecological and economic models, and collection of basic biological and economic data required as inputs for the models,
iii) to discuss specific areas where the present state of knowledge may allow quantification of the economic aspects of marine mammal-fisheries interaction;
    a) what could be the economic consequences of a total stop in harp seal exploitation, versus different levels of continued sustainable harvest?
    b) what could be the economic consequences of different levels of sustainable harvest vs. no exploitation of minke whales?

The Working Group on the Economic Aspects of Marine Mammal - Fisheries Interactions met in February 2000 to consider parts i) and ii) of the request. One of the conclusions of the Working Group was that significant uncertainties remain in the calculation of consumption by marine mammals, and this uncertainty was the most important factor hindering the development of models linking consumption with fishery economics (NAMMCO 2001). Considering this conclusion, the Scientific Committee decided to convene this workshop to further investigate the methodological and analytical problems in estimating consumption by marine mammals.

The Chairman emphasised that the main task of the current workshop would be to consider the methodological approaches to the calculation of consumption by marine mammals, making a detailed assessment of their relative merits. Although the estimation of marine mammal abundance is certainly also relevant to this topic, this will not be considered as it is the subject of another NAMMCO Working Group. The overall goal should be to make concrete recommendations on what approaches should be emphasised, and to make prioritised recommendations for further research in this area. The problems related to determining prey preference when more than one prey species is available, and the ecosystem responses to perturbations of the system by natural or anthropogenic causes (e.g. overfishing, culling of marine mammals) will not be discussed in the present workshop, but will probably be the main topic for a future NAMMCO workshop.

2. ADOPTION OF AGENDA

The draft agenda (Appendix 2) was adopted with minor changes.

3. APPOINTMENT OF RAPPORTEUR

Grete Hovelsrud-Broda, General Secretary, and Daniel Pike, Scientific Secretary of NAMMCO, were appointed as Rapporteurs for the meeting.

4. REVIEW OF AVAILABLE DOCUMENTS

The documents considered by the Working Group are listed in Appendix 3.

5. QUANTITATIVE DESCRIPTION OF MARINE MAMMAL DIETS

i. Stomach evacuation methods

Tjelmeland described the Norwegian program for determining the consumption of capelin by cod in the Barents Sea. This estimate is made annually and is used in the assessment of the capelin stock. The amount of capelin consumed by cod has a direct effect on the amount that can be taken by the fishery. The diet of cod is determined from a large sample (ca. 10,000) of cod stomachs collected throughout the distribution range and year. The evacuation rate of cod is determined experimentally in the laboratory by prey species, prey size and temperature. Estimates of cod numbers by size class are available from an annual assessment. A model is used to estimate consumption based on these inputs.

Prey consumption by minke whales in the North Pacific has been estimated using a method based on stomach evacuation rate as estimated from the diurnal change in stomach content weight (SC/9/EC/8). It is assumed in this method that minke whales do not feed at night, and that all prey takes 8 hours to digest. Average daily consumption estimated using this method was between 63 and 113 kg, in general agreement with the 48 to 287 kg estimated using a method combining estimates of field metabolic rate with observed diet.

In considering the applicability of stomach evacuation methods to marine mammals, the Working Group noted that evacuation must be determined experimentally under a wide variety of conditions, separately for each prey species and size, and that this was difficult for pinnipeds and impossible for most cetaceans. Such methods may only be applicable in areas and with species where a bolus feeding pattern prevails, and this is not the case for many species in the northern North Atlantic. The level of assumptions required and general lack of data about evacuation rate for most marine mammals render these methods unsuitable for the calculation of consumption by North Atlantic marine mammals.

ii. Diet composition from analyses of stomachs, intestines or faeces

In presenting some aspects of SC/9/EC/9, Lindstrøm noted that there were limitations and assumptions inherent in all types of dietary analysis, particularly those involving reconstruction of digested contents. A major limitation for stomach and intestinal analysis is that the animal must be killed for sample collection, so that resampling of an individual is impossible. Faecal samples are easy to collect from some pinnipeds and have the advantage of being available from live animals, making it possible to study an animal's foraging behaviour over several foraging events. However their interpretation is difficult because only non-digestible prey items remain and this may lead to bias due to differences in the passage and digestion rates of different species and sizes of prey. Additionally, a meal may be deposited in more than one scat, leading to a risk of autocorrelation between samples. Moreover, there are large differences between the passage and digestion rates of different prey species and prey sizes, and this is likely to affect the reliability of the diet composition estimates. For example large prey are digested more slowly than small prey, and this is likely to lead to overrepresentation of large prey in stomach samples. Hard parts such as fish otoliths, which are commonly used to estimate the original fish weight, are subject to degradation and retention in stomachs. Although correction factors continue to be developed to compensate for digestion of otoliths, we should be cautious making quantitative inferences of animals feeding behaviour when using digested food to reconstruct the diet composition.

Trites reported that errors associated with identifying the prey eaten by pinnipeds can be assessed using simulation models and captive feeding experiments. Models can be used to determine appropriate sample sizes to minimise the error in identifying types and numbers of species consumed. Captive feeding trials reveal which bones are most or least resistant to digestion. They also show the influence of fish size and total meal size on the likelihood of recovering bones of prey consumed.

Identifying all hard parts to species increases the likelihood of identifying all prey consumed. This is particularly important for large species whose heads are not eaten. Scats are thus a reliable means of identifying what species have been consumed. Furthermore, some recovered bones (such as otoliths) can be measured to estimate the size of fish consumed. Although research to date has concentrated on interpreting scat samples, analogous methods could be applied to stomach samples. However, differences in the relative digestibility of different species of prey, and the effects of pinniped activity and the presence of foreign objects in the stomach are not yet understood sufficiently to allow accurate estimates of numbers and sizes of prey consumed.

The Working Group concluded that the proportions of various prey items in the diet can be derived from undigested items in fresh stomach samples. Interpretation becomes increasingly more difficult as digestion proceeds. However it was noted that a proportional diet can be derived even from faecal samples if a large number of samples is available and the prey items are treated as presence/absence and of equal abundance. Table 1 presents a comparison of the advantages and disadvantages of various methods of determining diet composition.

Problems in determining the consumption of capelin by harp seals

In presenting SC/9/EC/7, Tjelmeland noted that modelling tools used in the assessment of commercial fish species in the Barents Sea are specific to species. Cod and herring stocks are assessed by calibrating simple population models to trends in time series data. The capelin assessment is founded on an annual acoustic survey conducted in September.

The mature part of the capelin stock will spawn about April 1 and there are no additional measurements of the spawning stock after September. The capelin dies after spawning. The capelin stock is managed using spawning stock-based biological reference points. At present, the consumption by harp seal on capelin during the period October to April is neglected. It would be important to quantify the mortality generated by consumption by harp seals during this period. However, the available stomach content data are inadequate for that purpose, because the samples have as a rule been restricted to the areas along the ice edge. Also, the understanding of the geographical overlap between capelin and harp seals in this period is poor.

The natural mortality of the immature capelin is estimated from data and consequently a quantification of the consumption by harp seal during April – September is less important.

Annual consumption of herring and cod by harp seal can be included as an additional catch in the current assessment procedures for cod and herring. However, the consumption should be dis-aggregated on prey age.

A co-operation between Fiskeriforskning (Tromsø), the Institute of Marine Research (Bergen) and the Knipovich Polar Research Institute of Marine Fisheries and Oceanography (PINRO, Murmansk) has been started in order to improve the data basis for a quantification of the consumption of fish by harp seal.

In discussion the Working Group observed that this work demonstrated the need for the collection of samples from the entire range of the animal and at every time of the year, as diet may change greatly with changes in the distribution of prey species. Unfortunately sampling is all too often limited the areas where samples can be collected easily. Telemetry will also be useful in defining the amount of overlap between marine mammal and fish distributions, provided the distribution of relevant fish species is available.

Estimating diets of harp seals off Newfoundland, Canada.

SC/9/EC/5 described the diet of harp seals off the coast of Newfoundland as estimated from the stomach contents of seals collected since 1979. The reconstructed wet weights of ingested prey were estimated from a total of 5,567 prey-containing stomachs collected in 1982 and between 1986 –1998 using methods described in Lawson *et al*. (1995). Of these, 4,453 stomachs were from the east coast of Newfoundland and southern Labrador, Canada (NAFO Divisions 2J3KL). Samples were assigned to either a winter (Oct. – March) or spring (April – Sept.) season and divided into geographical areas based upon designated NAFO areas and distance from shore. The vast majority of samples (93.8%) were obtained from the nearshore area (defined as <25 km from headlands). More samples were obtained during the winter period (n=3,270) than during the spring (n=1,183) due to the seasonal migration of seals out of the area during the summer.

Prey lengths and weights were estimated from direct measurements of undigested prey or using hard parts using part length – total length and part length – and/or length – weight regression equations. If hard parts were too digested or eroded to measure accurately, an average value was calculated for that prey species based on measurable otoliths in the stomach or from samples taken from seals collected at the same area during the same year and season. The use of different regressions was found to result in different estimates of prey weights and lengths. Therefore, regressions based on fish collected in the local area were used as much as possible. Reconstructed wet weights were converted to energy densities using published energy values for each prey species.

To estimate uncertainty associated with diets, samples were grouped according to location and season of collection and simulated data sets of total energy consumed were created using a bootstrapping (i.e. resampling-with-replacement) technique. Each stomach was treated as a unit for resampling purposes. This process was repeated 1000 times to generate estimates of total mass and hence energy, from which proportions contributed by each prey group could be calculated. Visual examination of these distributions suggested that they were approximately normal. Although there is uncertainty associated with the use of regression equations to estimate prey weight, the additional contribution to the overall uncertainty is likely small and not included.

When samples from all years were pooled across years to estimate an average diet for the time period, the greatest proportion of energy in the winter nearshore diet came from Arctic cod (*Boreogadus saida*, 53.85%, SE=1.5), Atlantic herring (14.51%, SE=1.02) and capelin (9.08%, SE=0.55). Capelin (61.42%, SE=7.6) were the largest contributor in offshore areas although there was greater variation than in nearshore areas. American plaice (12.75%, SE=7.79), unidentified pleuronectidae (8.34%, SE=4.72) and shrimp (7.56%, SE=2.01) were also common contributors to the diet.

In discussion it was noted that the proportion of Atlantic cod in the nearshore diet of harp seals has not decreased since the 1980's, despite the near total collapse of the cod stock in the area. The offshore diet was based on relatively few samples as compared to the nearshore even though harp seals are known to spend the majority of their time feeding in offshore waters.

There was general concern that hard parts such as otoliths may underrepresent a prey item in a stomach sample if only part of the prey is eaten. This has been observed among harp seals. This is an area where the supplementary techniques described under 5.iii. may prove particularly useful in determining if hard parts provide an accurate estimation of the representation of the prey item in the diet.

iii. Diet composition from fatty acids, isotopes and proteins

Although the Working Group had no papers that dealt directly with this topic, published papers have shown that the methods are useful for some purposes. In general they give an integrated view of feeding over large spatial and temporal scales. They are effective in detecting qualitative changes in feeding over the year or life history of the animal. They are also useful for obtaining information on diet from areas and time periods from which information from traditional methods is not obtainable. However these methods have not as yet proven capable of providing detailed (e.g. species composition) quantitative information on the diet of individual animals, and some members were of the view that there was little hope that they ever would. They must therefore be supplemented with traditional methods of diet determination and are not in themselves adequate for use in estimating consumption.

iv. Diet composition from feeding behaviour

Data loggers and telemetry

Folkow presented information on how data obtained by the remote monitoring of marine mammals, using either data loggers or satellite-linked time-depth recorders, may be used to evaluate the diet composition of the tagged species in the areas in which they operate. The approach is based on comparing data on the temporal and spatial distribution of the predator, including its vertical movements (dive depths), with similar data for potential prey species, in order to identify matches that may indicate the likely prey species of the predator. This approach is of particular interest when studying species such as harp and hooded seals, which, due to their migratory and dive behaviour, are not readily accessible for traditional diet composition studies based on collections of stomach/intestinal/faecal samples.

Data from recent satellite-telemetry studies of harp seals from both the Greenland Sea and Barents Sea populations, as performed by representatives of the Department of Arctic Biology, University of Tromsø, were presented to exemplify the type of data that may be provided by use of this approach. This includes data on the geographical area in which the tagged animals operate at different times of the year, their diving behaviour (dive depths) within these areas, which, when related to bathymetry, may indicate whether they were feeding on benthic or pelagic prey. Moreover, potential temporal (diurnal) changes in diving depths within an area may indicate whether the prey performed diurnal vertical migrations or not, which may represent yet another cue as to what type of prey the predator was feeding on. The approach has obvious limitations, the most prominent ones being related to the often quite small sample size (due to the large costs associated with tagging) and the question of how to identify the likely prey in cases where more than one candidate exists. It was also emphasised that the approach depends heavily on the spatial and temporal resolution and quality of the fisheries resource data, which in most cases is much coarser than is the case for the distribution and dive behaviour data that may be collected from the predator.

Boyd presented information on animal-mounted video cameras, which are beginning to be used to examine the foraging behaviour of pinnipeds. This method has been restricted to use on animals that can be recaptured and is therefore presently not useful for most North Atlantic marine mammals. However the method has some potential to provide additional information about diet.

In discussion the Working Group noted that the co-occurrence of predators and prey in time and space is highly indicative of predation, but confirmatory observations by other means are always required. The difference in spatial and temporal scales between fisheries surveys and telemetric tracking data is problematic, but additional information can be gained by monitoring fishing activities in the area as well. Extension of this work will require closer collaboration between marine mammal and fishery scientists at both national and international levels.

General discussion

It is apparent that valuable information on diet can come from a variety of sources, and that some methods are suitable for some species, times and areas, but impossible or of limited use for others. The advantages and disadvantages of various methods are summarised in Table 1, and their applicability to various species is described in Table 2.

The challenge remains to integrate information from a variety of sources to get a better quantitative picture of diet, along with the uncertainty associated with its estimation. To do this will require the process of diet determination to be dis-aggregated into its component parts, including components related to spatial and temporal distribution, and the age, sex and reproductive status of the predator, and the energy density of the prey. Data from different sources, along with estimates of precision, can then be entered into the appropriate part of the framework. If no data exists, appropriate “guestimates” can be used. Uncertainty in the estimation of diet can then be estimated by resampling techniques. The Working Group developed an example of such a framework, described in Annex 1.

6. ESTIMATING ENERGY CONSUMPTION

i. Baleen whales

Determination of field metabolic rate from energy expenditure

Blix explained how the energy expenditure (field metabolic rate) of free swimming minke whales has been determined from records of respiratory rate and lung capacity measurements, as described in Blix and Folkow (1995). From this effort a value of 80 kJ. kg^{-1} day^{-1} was obtained for a 4000 kg animal.

The working group agreed that although there are uncertainties with regard to oxygen extraction and the tidal volume fraction of the measured lung capacities, this estimate provides a useful value for the field metabolic rate of minke whales, which is 2.2 times the basal metabolic rate as estimated by Folkow and Blix (1992). Minke whales are amenable to this methodology because they breathe only once during each surfacing, the breathing frequency seems constant over large areas, and like other whales, the tidal volume does not vary with physical activity.

Estimating energy use for tissue deposition

In order to calculate energy consumption of minke whales staying in the Northeastern Atlantic during summer time, one factor that has to be taken into account is the amount of energy stored in tissues, such as blubber or growth of a foetus. Nordøy presented information gathered during the Norwegian scientific minke whaling program when a number of minke whales caught early in the summer season (average catch date: mid-May) and late in the summer season (average catch date: mid-September) were dissected and the amount of muscle mass, blubber mass and visceral fat determined. The energy density of samples of the different tissues were determined by bomb calorimetry and the total amount of energy stored into blubber, muscle mass, visceral fat and growth of foetus determined for an assumed stay of 180 days in Northeast Atlantic waters. The calculations suggest that, on average, about 150,000 kJ is deposited per day as tissue energy during this period in an adult (6,000 kg) whale. This amounts to 35% of daily energy expenditure. It can moreover be calculated that this amount of energy can only cover some 30% of the energy expenditure, when the whales are supposed to be in other waters. The energy consumption for different age classes and sex of minke whales was determined by combining the above data with data on energy expenditure and urinary and faecal energy loss.

In discussion the Working Group noted the relatively high gross efficiency of 35%. The residence time of 180 days is an important assumption in the model. Very few whales are detected in early spring, at a time when there is good enough light to see them if they were there. It is possible that some minke whales stay during the dark winters, but observations of migratory patterns suggest that most whales leave the area during winter. Nothing is known about the whereabouts of juveniles, but it is thought that new-borns could not survive in the cold winter water. The body condition of the minke whales in spring suggests that they do not feed as much in winter, because most of the blubber has disappeared.

ii. Seals

Free ranging animals

Boyd presented a range of methods available for measuring metabolic rate in the field. These mainly include indirect respirometry and include the use of single- and double-labelled water, and heart rate. All methods have limitations. A relatively small total number of individuals are usually included within studies and these usually include a narrow range of size, age and sex classes. Since information is mainly restricted to a narrow range of age, size and sex classes from a narrow range of species, it is necessary to extrapolate among age, size and sex classes and also among species.

There is a requirement to develop a method that will allow the estimation of metabolic rate of seals that range over large distances and that cannot be recaptured. There was discussion of the use of heart rate as an indicator of metabolic rate that could be measured over time periods of multiple months. While the Working Group recognised that there were potentially important limitations of this method, it appears currently to be the only candidate for development into a method for measuring field metabolic rate of species such as harp and hooded seals throughout the year. This will require further validation of heart rate and the development of instrumentation to allow the transmission of data to a satellite.

Captive animals

One alternative method of obtaining information on the energy consumption of wild seals is to use information on the level of food intake of captive animals fed food with known energy density. The relatively small body size of the harp seals compared to baleen whales, like minke whales, makes it feasible to obtain long-term measurements of food intake on a number of captive animals. Nordøy reported on a study in which three four year old harp seals were kept under controlled conditions for a year and the exact daily food intake was monitored. The experimental photoperiod simulated the outdoor photoperiod at 70°N, while water temperature was close to natural. Body condition was monitored by labelled water techniques, while activity was recorded through wave movements. The harp seals displayed seasonal changes in appetite, activity levels and fattening which correlates with information from wild populations. Also food intake, expressed as percent of body mass, varied between 1.5 and 5% depending on the season. On average, the energy consumption or Gross Energy Intake was about 26,000 kJ/day for an average body mass of about 81 kg, which when corrected for loss of energy through faeces and urine, corresponds to a field metabolic rate (FMR) of about 2.7 times basal metabolic rate (Kleiber). Under certain assumptions such estimates of energy consumption can be used to calculate total food consumption of wild harp seal populations.

The Working Group considered that the determination of FMR in captive animals was a valuable approach, but that some means was needed to correlate these observations with free-ranging animals. It has been shown through satellite tag deployments that harp seals spend 80 to 90% of their time diving, an activity that is not reproducible under conditions of captivity. It is possible that the FMR of free ranging animals may actually be lower than that of captive animals in some cases.

7. METHODS FOR INTEGRATING CONSUMPTION, ABUNDANCE AND DISTRIBUTION INFORMATION

Trites presented three different approaches to estimating the amount of food consumed by marine mammals.

The first is a multispecies or ecosystem approach, which estimates the amount of energy flowing to marine mammals from their prey. Ecopath is a software package that uses mass balance principles to model ecosystem dynamics. Six parameters are required for each species or group of species in the ecosystem. They include biomass (total weight of all age classes), diet composition (the fraction of different species consumed), consumption (the amount consumed per year), production (accumulated and lost biomass), ecotrophic efficiency (the fraction of production passed up the food web) and export (what leaves the ecosystem). This approach is informative about the relative amounts of prey consumed by different species within the ecosystem, but estimates may not be particularly precise.

A second approach to modelling consumption by marine mammals applies the following framework

$$Q_i = \sum_s N_{is} W_{is} R_{is}$$

where Q_i is consumption by species i, N is the number of individuals by sex s of species i, W is the mean individual weight by sex and species; and R is the daily ration for an individual of weight W. This simple model can be applied to species of marine mammals about which little is known.

A third approach for modelling gross energy requirements (*GER*) uses the following framework:

$$GER = \frac{P + (A \times BM)}{E_{HIF} \times E_{f+u}}$$

where *P* is production or energy deposition, *A* is an activity metabolic multiplier, *BM* is basal metabolism, E_{HIF} is the efficiency of utilisation of metabolizable energy (or 1 – heat increment of feeding as a proportion of metabolizable energy), and E_{f+u} is fecal and urinary digestive efficiency (metabolizable energy as a proportion of gross energy). This detailed approach can be used to estimate the energy requirements for each age, sex, reproductive status (immature, mature, pregnant), and day of the year.

Working paper SC/9/EC/6 used this detailed approach to estimate the energy requirements of Steller sea lions. Most model parameters (means and standard errors) were derived from captive experiments and field observations of sea lions. Some parameters were drawn from studies of other pinnipeds. Parameters were selected at random (from their estimated distributions), and the model was run 1,000 times to yield a mean estimate (plus standard deviation) of gross energy requirements. A sensitivity analysis indicates that most of the uncertainty in model estimates for Steller sea lions can be attributed to uncertainty in basal metabolism and the activity multiplier (*A BM*), and suggests directions for future research.

All three approaches to modelling bioenergetics offer different, but complementary insights into the amounts of prey consumed by marine mammals.

In discussion the Working Group expressed some surprise at the high consumption estimated for juvenile animals in SC/9/EC/6, up to 13% of body weight per day. Some members felt that this was unrealistically high; this might relate to concerns about the formulation of the equation for GER above. The Working

Group also noted that in other areas, population parameters have been among the largest contributors to the variance of the consumption estimate, whereas in this case uncertainty about metabolic rate was the major factor. This is presumably dependent on the precision of the available estimates of population size, age structure, etc., which are quite low for most populations. However there is some subjectivity in the estimation of precision, because for some components of the model precision is not known and best guesses must be substituted.

Estimates of precision are not presently implemented into Ecopath models so the results may be misleading. However they do provide an excellent framework for incorporating data from a variety of sources and gaining a better understanding of the role of the predator in the ecosystem.

Estimating the consumption by NW Atlantic harp seals

In SC/9/EC/5, consumption of prey by harp seals in NAFO divisions 2J3KL was estimated using a bioenergetics model that integrates information on the numbers at age, age-specific energy requirements, seasonal distribution and diet of the predator. Abundance was estimated using a population model integrating pup production, annual estimates of reproductive rates and data on age-specific removals. Energy requirements were estimated using age specific body mass. The proportion of energy obtained off Newfoundland was considered proportional to the residency time of seals in the area based on results of satellite telemetry and traditional tagging studies. The diet of harp seals in nearshore and offshore waters during winter and spring was determined by reconstructing the wet weight of stomachs collected in 1982 and 1986-1998. Uncertainty in the consumption estimates were approximated by incorporating the variance in the numbers at ages, diets and seasonal distribution into the model using resampling procedures. Capelin and Arctic cod were the primary prey consumed while Atlantic cod was a relatively small component of the individual diets. Based on their average diet, harp seals consumed an estimated 893,000 (95% CI: 682,000-1,100,000) tonnes of capelin, 185,000 (95% CI: 58,000-457,000) tonnes of Arctic cod and 37,000 (95% CI: 14,000-62,000) tonnes of Atlantic cod in 2000. Improvements in estimates of consumption can be achieved by further diet sampling in offshore areas and increased information on residency of seals of all ages in the area. However, estimates will likely remain quite variable owing to the strong temporal and spatial changes in diet composition.

Rosing-Asvid pointed out some factors that might influence the outcome of the consumption model presented in SC/9/EC/5. The distribution of the harp seals found by telemetry is based on animals released around Newfoundland in late May-June. By this time the number of adult harp seals in Greenland is already peaking and these early –migrating animals are therefore not included in the seasonal distribution used in the model. The migration pattern is likely to be influenced by the time by which the animals start to migrate, because the optimal foraging strategy may be different for an animals that starts to migrate in late April compared to an animal that starts to migrate in mid June. It is therefore important to distribute the transmitters so the early migrants and all age and sex groups are included.

Data was presented indicating that harp seals start to leave Greenland not as one unit, but with fat seals leaving first, and it was argued that weight increases in one area might be caused by the influx of fat animals and not necessarily fat gained in the area. In order to derive a model that takes care of these kinds of energy transfers when calculating consumption in particular areas, the mean weight and energy content of the stomachs from that area should be incorporated.

In discussion the Working Group noted the observation that it appears that Northwest Atlantic harp seals hardly ever leave shallow waters, just as in the Barents Sea. Seals off the coast of East Canada are not usually found in waters deeper than 400-500 meters. Seals were observed to stay mainly on the shelf and move quickly between shelf edges.

The energy density differed by 100% between the age groups of prey, in particular herring, and it was not possible to distinguish between the spawning capelin from the rest of the fish. The energy density of the spawning products is the same as the rest of the fish.

8. RESEARCH NEEDS

Background

Previous recommendations (NAMMCO 2001) to move beyond point estimates of consumption to address the range of uncertainties in these estimates are being pursued (e.g. SC/9/EC/4, 5 and 6)). It is important to take account of all sources of uncertainties in such computations, even if this requires subjective assessment of the range and probability distribution appropriate to factors which are poorly known (see also Annex 1).

Such exercises also provide guidance on research priorities, as they quantify the proportions of the overall uncertainty in consumption estimates that is attributable to each of the component factors. Priority should then be given to research aimed at improving knowledge on those factors which contribute most to the overall uncertainty. There is little point in investing resources in a factor that contributes little to the overall uncertainty, if improvements are not first possible for other more influential factors.

In discussion, the question was raised as to how to account for "uncertainties about uncertainties" when dealing with factors for which probability distributions need to be specified in a more subjective manner. It was suggested that computations be repeated for each of the different specifications of such distributions by a number of scientists involved in the research concerned. What is important is the ranking of factors as regards their impact on the overall uncertainty in a consumption estimate. It was suggested that consumption estimate exercises for the marine mammals and regions of interest be conducted on this basis, i.e. incorporating full evaluation of all uncertainties.

It was further suggested that attention would need to be given as to what aspects of consumption estimates were most influential as regards conclusions concerning the possible impact of marine mammals on fishery catches. While estimates of consumption would be important, it could be that estimating the extent to which such consumption and its components by species change in response to changes in prey species abundance will prove even more important. This may affect research priorities.

Specific Research Recommendations

The following were identified as the most important matters needing additional attention:

- Field metabolic rate of harp and hooded seals;
- Distribution of prey species in space and time;
- Spatial and temporal distribution of the diet composition of harp and hooded seals;
- Temporal changes in energy density of prey species;
- Diet of minke whales in Icelandic waters and further west;
- Consumption estimates synthesised within a modelling framework including full uncertainty evaluation;

The next workshop should *inter alia* consider which aspects of consumption estimates are likely to be most influential for calculating the possible impact of marine mammals on fishery catches

9. ADOPTION OF REPORT

The Report was adopted by the Working Group on September 28, 2001 at 1615. The Working Group expressed its thanks to Professor Blix and his department for hosting the Workshop, NAMMCO for the practical arrangements and Walløe for his chairmanship.

REFERENCES

Blix, A.S. and Folkow, L.P. 1995. Daily energy expenditure in free living minke whales. *Acta Physiol. Scand.* 153: 61-66.

Folkow, L.P. and Blix, A.S. 1992. Metabolic rates of minke whales (*Balaenoptera acuto-rostrata*) in cold water. *Acta Physiol. Scand.* 146: 141-150.

Lawson, J. W., G. B. Stenson, and D. G. McKinnon. 1995. Diet of harp seals (*Phoca groenlandica*) in nearshore waters of the northwest Atlantic during 1990-1993. *Can J. Zool.* 73: 1805-1818.

[NAMMCO] North Atlantic Marine Mammal Commission. 1998. Report of the Working Group on the Role of Minke Whales, Harp Seals and Hooded Seals in the North Atlantic Ecosystem. In: NAMMCO, *NAMMCO Annual Report 1997*, Tromsø, p. 125-146.

[NAMMCO] North Atlantic Marine Mammal Commission. 1999. Report of the Working Group on Economic Aspects of Marine Mammal - Fisheries Interactions. In: NAMMCO, *NAMMCO Annual Report 1998*, Tromsø, p. 107-116.

[NAMMCO] North Atlantic Marine Mammal Commission. 2001. Report of the Working Group on Economic Aspects of Marine Mammal - Fisheries Interactions. In: NAMMCO, *NAMMCO Annual Report 2000*, Tromsø, p. 169-202.

Table 1. Relative merits of various methods of determining the diet composition of marine mammals.

Method	Advantages	Disadvantages
Stomach	i) Information on meal size and composition; ii) Information tied to an individual; iii) Easy to obtain samples from a hunt, bycatch or cull;	i) Resampling of individuals impossible; ii) Sampling not possible in small, localised populations iii) Sample size small relative to total population; iv) Sampling may be biased with respect to space, time, age/size/class structure of the population ; v) Potential correlation between samples
Intestine	i) Potentially integrates across several meals; ii) Information tied to an individual; iii) Easy to obtain samples from a hunt, bycatch or cull;	i) Resampling of individuals impossible; ii) Sampling not possible in small, localised populations iii) Sample size small relative to total population; iv) Sampling may be biased with respect to space, time, age/size/class structure of the population v) Loss of resolution of prey composition vi) Potential correlation between samples
Scat- Hard Parts	i) Potentially integrates across several meals; ii) Relatively easy to obtain samples for some species; iii) Non-lethal and non-invasive; iv) With appropriate spatial and temporal stratification could provide an accurate indication of diet in species that haul-out regularly v) Sampling of small/localised populations is possible vi) In some species, unlimited sample size.	i) Not applicable to species that rarely haul-out; ii) Resampling of individuals is difficult; iii) Samples may not be independent; iv) Potential for bias when there is spatial and temporal heterogeneity in diet; v) Substantial loss of resolution of diet composition vi) Information tied to an individual if accompanied by molecular genetics, and this is costly.

Method	Advantages	Disadvantages
Scats - Proteins or DNA	i) Potentially integrates across several meals; ii) Relatively easy to obtain samples; iii) Non-lethal and non-invasive; iv) With appropriate spatial and temporal stratification could provide an accurate indication of diet in species that haul-out regularly v) Sampling of small/localised populations is possible vi) In some species, unlimited sample size.	i) Does not work in all circumstances? ii) Requires large amount of data about proteins in prey species; iii) Information tied to an individual only if accompanied by molecular genetics, and this is costly; iv) Potential for bias when there is spatial and temporal heterogeneity in diet;
Fatty acid signature analysis	i) Integrates over long time scales; ii) Samples relatively easy to obtain from lethal or non-lethal sampling; iii) Relatively non-invasive; iv) Resampling of individuals may be possible;	i) Require large amount of information about prey fatty acids; ii) Coarse resolution; iii) High cost; iv) Potential for bias when there is spatial and temporal heterogeneity in diet; v) Heterogeneity of distribution in tissues. vi) Quantitative description of diet not currently possible.
Stable isotopes	i) Integrates over very long time scales; ii) Samples relatively easy to obtain from lethal or non-lethal sampling; iii) Relatively non-invasive; iv) Resampling of individuals may be possible; v) Historical sampling is possible;	i) Very coarse resolution; ii) Requires large amount of information about isotopic levels in prey. iii) High cost; iv) Potential for bias when there is spatial and temporal heterogeneity in diet; v) Heterogeneity of distribution in tissues. vi) Quantitative description of diet not currently possible
Satelite Linked Time Depth Recorder/Time Depth Recorder	i) Longitudinal information for individuals; ii) Sampling over large spatial and temporal scales; iii) Information is spatially and temporally explicit iv) Linked to specific individuals	i) Lack of ground-truthing ii) Not easily applied to large cetaceans; iii) Costly, implying small sample size of individuals; iv) Depends on the availability of fishery data. v) Relatively indirect.

Method	Advantages	Disadvantages
Camera	i) Highly detailed information about prey encountered; ii) Linkage to specific behaviour and locations; iii) Linked to specific individuals	i) Recovery of data is difficult in most circumstances; ii) Small sample size; iii) Not easily applicable to all species; iv) Short record duration, i.e. sampling over small spatial and temporal scales; v) Prey encountered may not equal prey ingested
Direct Observation	i) Detailed information about location and timing; ii) Possible prey identification; iii) Linkage to individuals in some species;	i) Applies to a narrow range of species and situations; ii) Possible sampling bias, including observer effects; iii) Small sample size

Table 2. Scientific applicability of methods of diet determination to some North Atlantic taxa of marine mammals. If no *, method is not applicable; if ***, method is very applicable.

	Stomach[1]	**Intestine**[1]	**Scat - Hard Parts**	**Scat - Protein/ DNA**	**Fatty Acid Signature Analysis**	**Stable Isotope**	**Time Depth Recorders**[2]	**Camera**	**Direct Obser-vations**
Minke	***	**			*	*	*		*
Dolphins	***	**			*	*	*		*
Harp	***	**			*	*	**		
Hooded seal	**	**			*	*	**		
Grey seal	*	**	***	*	*	*	**	*	
Harbour seal	*	**	***	*	*	*	**	*	

[1]Applicability limited in time and space for logistic and political reasons.
[2]Applicability depends on information on prey distribution.

Annex 1

FRAMEWORK MODEL FOR QUANTITATIVE DETERMINATION OF CONSUMPTION

The annual consumption (C) by a predator of a particular species is basically calculated as:

$$C = N \times R \times p$$

where N = number of predators
R = annual food intake requirement for predator
p = proportion of diet made up by a species of interest.

The computation becomes complicated because neither N nor p are "homogeneous". Both may depend on space, time of year, predator age and predator sex. As predator requirements are in terms of energy, strictly R relates to energy rather than mass intake. This introduces further non-homogeneity considerations. First the energy content per unit mass of prey differs between prey species, and also within a species at different times of the year. Secondly, the predators own energy requirements vary with season. For ease of presentation, these considerations are not pursued further below, but the approach can readily be extended to take them into account.

Thus one needs to calculate:

$$C = \sum space \sum time \sum age \sum sex (N \times R \times p)$$

Difficulties then arise because of absence of information on either of N or p when data are disaggregated into these "strata" for the computation.

Consider a simple example for N which ignores age and sex, and has 2 strata for each of space and time. Ideally what is wanted is to estimate proportions (shown as percentages) along the lines indicated in the following matrix:

Time	**Area 1**	**Area 2**
Summer	25 ± 5	75 ± 5
Winter	60 ± 10	40 ± 10

The first figure in each block indicates the true (but unknown) average proportion of the predator population in the stratum, while the second represents the extent to which this proportion varies between years.

Typically different sources of data will provide information on some but not all of the entries in such a matrix. to be able to combine such data sources in an optimal way to best estimate the values for the matrix as a whole, it is important to clarify first as to exactly which entries each source of data provides information upon.

For example, an annual summer survey over two years would provide information on all entries in the top row of the example matrix above. In contrast, satellite tagging over one year could provide information on all average value entries in the matrix, but not on the interannual variability. Dis-aggregated information on species proportion in the diet (p) can be dealt with similarly to numbers (N) above. There are statistical methods available (e.g. maximum likelihood estimates) which can combine two such sources of information to provide best estimates of all the entries shown in the matrix, together with estimates of the precision of each.

Some methods yield information too crude to evaluate on such a basis. While best "guestimates" can be used in such circumstances, these in isolation have the problem of failing to take account of the associated uncertainty in the overall estimates of imprecision of consumption estimates. What is needed here is to select not only the single best "guestimate", but to provide a range of possible values with an informed judgement on the relative probability accorded to each. By repeated sampling from this distribution in performing computations, such uncertainty can be reflected in overall results.

Appendix 1

LIST OF PARTICIPANTS

Prof. Arnoldus Schytte Blix
Department of Arctic Biology
University of Tromsø
9037 Tromsø, Norway
Tel: +47 77 64 48 67
Fax: +47 77 64 57 70
E-mail: asblix@fagmed.uit.no

Dr I.L. Boyd
Sea Mammal Research Unit
Gatty Marine Laboratory
University of St Andrews
St Andrews, Fife
Scotland KY16 8LB
Tel: 01334-463628
Fax: 01334-462632
E-mail: ilb@st-andrews.ac.uk

Dr Doug Butterworth
Dept. of Applied Mathematics
University of Cape Town
Rondebosch 7700
South Africa
Tel: +27 21 650 2343
Fax: +27 21 650 2334
E-mail: DLL@maths.uct.ac.za

Dr Peter Corkeron
Norwegian Institute of Fisheries and Aquaculture
N-9291 Tromsø, Norway
Telone: +47 77 62 92 29
Fax: +47 77 62 91 00
E-mail: peter.corkeron@fiskforsk.norut.no

Dr Lars Folkow
Department of Arctic Biology
University of Tromsø
N-9037 Tromsø, Norway
Tel: +47 77 64 47 92
Fax: +47 77 64 57 70
E-mail: larsf@fagmed.uit.no

Dr Grete Hovelsrud-Broda,
North Atlantic Marine Mammal Commission,
Polar Environmental Centre,
N-9296 Tromsø, Norway
Tel: +47 77 75 01 78/80
Fax: +47 77 75 01 81
E-mail: gretehb@nammco.no

Dr Ulf Lindstrøm
Norwegian College of Fishery Science,
University of Tromsø
N-9037 Tromsø,
Norway
Telone: +47 77 64 61 07
Fax: +47 77 64 60 20
E-mail: ulfl@nfh.uit.no

Dr Erling S. Nordøy
Department of Arctic Biology
University of Tromsø
N-9037 Tromsø, Norway
Tel: +47 77 64 47 94
Fax: +47 77 64 57 70
E-mail: erlingn@fagmed.uit.no

Mr Daniel Pike
North Atlantic Marine Mammal Commission,
Polar Environmental Centre,
N-9296 Tromsø, Norway
Tel: +47 77 75 01 77/80
Fax: +47 77 75 01 81
E-mail: dan.pike@nammco.no

Mr Aqqalu Rosing-Asvid
University of Copenhagen
Zoological Institute, Department of Population Ecology
Universitetsparken 15, 2100 København Ø
Tel: +45 35 32 12 92
Fax: +45 35 32 12 50
E-mail: arosing-asvid@ZI.ku.dk

Dr Garry Stenson
Science Branch, Department of Fisheries and Oceans,
PO Box 5667,
St. John's, Newfoundland,
Canada A1C 5X1
Tel: +1 709 772 5598
Fax: +1 709 772 2156
E-mail: stensong@dfo-mpo.gc.ca

Dr Tsutomu Tamura
Institute of Cetacean Research
Tokyo Suisan Bldg., 4-18, Toyomi-Cho, Chou-Ku, Tokyo 104
Japan
Tel: +81-3-3536-6521
Fax: +81-3-3536-6522
E-mail: tamura@i-cetacean-r.or.jp

Mr Sigurd Tjelmeland
Institute of Marine Research
P.O. Box 1870 Nordnes
N-5024 Bergen, Norway
Tel.: + 47 55 23 84 21
Fax.: + 47 55 23 86 87
Email: sigurd.tjelmeland@imr.no

Dr A. Trites
Marine Mammal Research Unit
Fisheries Centre
Department of Zoology, University of British Columbia
Hut B3, Room 18, 6248 Biosciences Rd.
Vancouver
British Columbia V6T 1Z4
Canada
Tel: +1 604 822-8181
Fax: +1 604 822-8180
E-mail: trites@zoology.ubc.ca

Mr Gísli A. Víkingsson
Marine Research Institute
P.O.Box 1390
IS_121 Reykjavik
Iceland
Tel: + 354 55 20240
Fax: +354 56 23790
E-mail: gisli@hafro.is

Dr Lars Walløe
Department of Physiology
University of Oslo
P.O. Box 1103, Blindern
N-0317 Oslo
Norway
Tel: +47 22 85 12 18
Fax: +47 22 85 12 49
E-mail: lars.walloe@basalmed.uio.no

Appendix 2

AGENDA

1. Opening remarks
2. Adoption of Agenda
3. Appointment of Rapporteur
4. Review of available documents
5. Quantitative description of marine mammal diets
    - i. Stomach evacuation methods
    - ii. Diet composition from analyses of stomachs, intestines or faeces
    - iii. Diet composition from feeding behaviour
6. Estimating energy consumption
    - i. Baleen whales
    - ii. Seals
7. Methods for integrating consumption, abundance and distribution information
8. Research needs
9. Adoption of report

Appendix 3

LIST OF DOCUMENTS

Document No.	Document Name
SC/9/EC/1	Draft list of participants
SC/9/EC/2	Draft agenda
SC/9/EC/3	Draft list of documents
SC/9/EC/4	Boyd, I.L. A generalised algorithm for estimating the energy, carbon and prey consumption of pinnipeds and penguins.
SC/9/EC/5	Stenson, G.B. and Perry, E. Incorporating uncertainty into estimates of Atlantic cod (*Gadus morhua*), capelin (*Mallotus villosus*) and Arctic cod (*Boreogadus saida*) consumption by harp seals in NAFO Divisions 2J3KL.
SC/9/EC/6	Winship, A.J, Trites, A.W. and Rosen, D.A.S. A bioenergetic model for estimating the food requirements of Steller sea lions (*Eumetopias jubatus*) in Alaska.
SC/9/EC/7	Tjelmeland, S. Consumption of capelin by harp seal in the Barents Sea - data gaps.
SC/9/EC/8	Tamura, T. Geographical and seasonal changes of prey species and prey consumption in the western North Pacific minke whales.
SC/9/EC/9	Lindstrøm, U. Foraging ecology of minke whales (*Balaenoptera acutorostrata*): Composition and selection of prey in the northeast Atlantic. Dr. Sci. Dissertation, University of Tromsø, 2001.
SC/9/EC/10	Fisheries Agency, Japan. Photographs taken during Japan's whale research in the Western North Pacific (JARPN II) in August and September 2000.

JOINT MEETING OF THE

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

AND THE

SCIENTIFIC WORKING GROUP OF THE JOINT COMMISSION ON THE CONSERVATION AND MANAGEMENT OF NARWHAL AND BELUGA

9-13 May, Qeqertarsuaq, Greenland.

1. OPENING REMARKS

Chairmen Jake Rice and Øystein Wiig welcomed the participants (Appendix 1) to the first joint meeting of the Canada/Greenland Joint Commission on Conservation and Management of Narwhal and Beluga (JCNB) Scientific Working Group and the North Atlantic Marine Mammal Commission (NAMMCO) Scientific Committee Working Group on the Population Status of Narwhal and Beluga in the North Atlantic (hereafter referred to as the Joint Working Group or JWG).

In 1999, the NAMMCO Council asked the Scientific Committee to provide advice on the level of sustainable utilisation of West Greenland beluga in different areas and under different management objectives, and to identify the information that is required to carry out a similar assessment for West Greenland narwhal. The Scientific Committee established a Working Group that took up these questions at their meeting in Oslo in June 2000. The Scientific Committee accepted the conclusions of the Working Group (NAMMCO 2000), that:

- The beluga stock that winters off West Greenland is substantially depleted and that present harvests are several times the sustainable yield, and, if continued, will likely lead to stock extinction within 20 years.
- Harvest must be reduced to about 100 animals per year to have any significant chance of stopping the decline in the stock within the next 10 years. The benefits of a delayed or graduated reduction in harvest must therefore be weighed against the increased risk of continued stock decline, and several possible scenarios for harvest reduction were presented.
- Developing recommendations on the sustainable harvest of narwhal in Greenland will require significant additional research and cannot be done at present.

The Joint Working Group agreed to use the findings of the NAMMCO Scientific Committee (NAMMCO 2000) as a starting point for their deliberations. However, the JWG expected to draw its conclusions based on the merits of the deliberations at this meeting, and would not be bound *a priori* by conclusions of the NAMMCO meeting last year. The Joint Working Group received the following requests for advice from JCNB and NAMMCO:

Advice Request from JCNB

- Recommend sustainable harvest level for beluga and narwhal under different management objectives.
- Are hunters from Nunavut and West Greenland hunting narwhal from the same stock(s)?
- Are the parameters used in Narwhal population model(s) adequate?
- What are the effects of potential errors in the ageing of narwhal (and beluga) on modelling of population growth rate and recommended harvest level?
- What are the effects of struck/lost on the recommended harvest level?
- What is the status of shared narwhal and beluga stocks and are the present harvest levels sustainable?

Advice Request from NAMMCO

- Investigate the impacts of ice entrapments on: (1) population (develop model to simulate effects on population) and (2) catch statistics.
- Examine the occurrence of ice entrapment events and the relationship to sea surface temperature.
- Examine past aerial survey data for: (1) detection probabilities of small vs. large pods and (2) estimation biases due to differing pod sizes among years. Re-examine the quality of the 1981 and 1982 aerial surveys. Are these surveys useful for trend analysis?
- Review results on the potential stock structure of beluga in west Greenland; specifically evaluate tooth morphology data and tagging data that will be available late in 2000.
- Models currently assume a 50:50 sex ratio in the harvest. Include data on sex ratio of the harvest in the models; evaluate results of the model and predicted impacts on the population of beluga and on recommended quotas.
- Conduct a formal and independent review of the model (formulation and estimation techniques) presently used in the assessment.
- Establish a method for formally collecting “anecdotal” data on beluga distribution and abundance in Baffin Bay and Davis Strait. These observations could be from surveys conducted for other projects or from local ecological knowledge.
- In addition, the Council asked the Scientific Committee to evaluate the extent of movements of narwhal between Canada and Greenland.

2. ADOPTION OF JOINT AGENDA

The agenda was adopted as written (Appendix 2).

3. APPOINTMENT OF RAPPORTEURS

Daniel Pike, Patrice Simon and Michelle Wheatley acted as primary Rapporteurs for the meeting.

4. REVIEW OF AVAILABLE DOCUMENTS

Documents that were available for the meeting are listed in Appendix 3. In addition to the scientific documents, the Joint Working Group received input from resource users during a meeting with Greenlandic and Canadian hunters that preceded the detailed technical discussion at the meeting, and from Canadian hunters who participated throughout much of the JWG meeting (see 7.1).

5. BELUGA

5.1 Stock Structure

SWG-2001-4: de March, B.G.E., Maiers, L.D. and Friesen, M.K. An overview of genetic relationships of Canadian and adjacent populations of belugas (*Delphinapterus leucas*) with emphasis on Baffin Bay and Canadian eastern Arctic populations.

Our current knowledge of the molecular genetics of high Arctic beluga populations (West Greenland, Lancaster Sound/Barrow Strait, Grise Fiord) and populations that are related (southeast Baffin, Beaufort Sea) (see Fig. 1 for locations), is presented. In general, genetic analyses confirmed the designation of putative stocks and suggested the existence of more stocks than previously described.

Comparisons based on mitochondrial DNA haplotypes showed that West Greenland (1992) belugas were significantly differentiated from Lancaster Sound/Barrow Strait, Kimmirut, Iqaluit, and/or Pangnirtung but not from Grise Fiord (AMOVA, table-wide $\alpha = 0.05$). Grise Fiord haplotypes were not significantly differentiated from Lancaster Sound/ Barrow Strait and not from southeast Baffin locations in some years. Lancaster Sound and southeast Baffin collections were not significantly differentiated from each other. These patterns existed for most years within locations, however a few yearly collections within major locations had different patterns. The collections that differed were small groups with few haplotypes, most likely relatives.

Patterns in microsatellite differentiation were slightly different than those for haplotypes. West Greenland and Grise Fiord microsatellites were not significantly differentiated from each other. However, Greenland differed from Lancaster Sound and southeast Baffin Island, while Grise Fiord did not. In southeast Baffin Island, Pangnirtung samples differed from Kimmirut using both haplotypes and microsatellites. Iqaluit samples had intermediate genetic characteristics between Pangnirtung and Kimmirut.

Patterns of significant differentiation among collections within locations was believed to be due to a combination of temporal patterns, sampling of relatives, chance, seasonal hunting, small sample sizes, and actual differences among populations.

SWG-2001-5 Innes, S., Muir, D.C.G., Stewart, R.E.A., Heide-Jørgensen, M.P. and Dietz, R. Stock identity of beluga (*Delphinapterus leucas*) in eastern Canada and West Greenland based on organochlorine contaminants in their blubber. (Presented by R. Stewart)
Beluga caught by hunters from various hamlets in the Arctic differed in the concentrations of organochlorine contaminants in their blubber. By applying Canonical Discriminant Analysis (CDA) it was possible to separate all seven sampling locations from each other. Over 90 per cent of the samples could be classified back to their landing location based on the data transformations developed by CDA. The analysis provides evidence that most beluga caught by hunters from Grise Fiord are not the same as beluga caught while migrating along West Greenland. It also suggested that there might be more than one stock in West Greenland. There is a need to redefine the stock descriptions of some beluga in Canada and Greenland. This analysis suggested that "stock" or management unit for beluga is best described by their migration route.

SWG-2001-6 de March, B.G.E., Stern, G. and Innes, S. The use of organochlorine contaminant profiles for stock discrimination – weaknesses and strengths of multivariate methods. A case study with beluga (*Delphinapterus leucas*) hunted in three communities on Southeast Baffin Island.
Concentrations of 64 of 88 organochlorine (OC) compounds examined differed among beluga samples from the three southeast Baffin communities of Pangnirtung (PA), Iqaluit (IQ), and Kimmirut (KI). In comparing PA and KI, levels were significantly different in 64 of 88 OCs examined; PA and IQ in 67/88 OCs, and IQ and KI in 19/88. ($Pr \leq 0.05$). On the basis of these results alone, it can be concluded that three stocks are represented.

However, it was difficult to assess the amount of overlap or mixing among stocks. The degree of differences among the three locations depended on which OCs were used in the analysis. In the model with all 88 OCs, 98 of 124 belugas were correctly identified to their source location (50 of 63 from PA, 27 of 37 from KI, and 21 of 24 from IQ). The best separation of belugas from locations (110/124 correctly placed) was obtained by allowing the model to sequentially pick the OCs that separated the locations best. Other models less prone to statistical artefacts correctly identified approximately 83 of 124 belugas correctly, (mean of 45 of 63 from PA, 22 of 37 from KI, and 16 of 24 from IQ). Caution is advised in accepting the results of such studies before scrutinising the statistical methodology. These results are similar to genetic results that also do not give sharp stock boundaries.

Although we confirm that there are at least three separate stocks of beluga that are hunted in the Southeast Baffin Island area instead of the putative single stock previously used for management purposes, we do not believe we can assign belugas back to their stock with great certainty. This is similar to genetic results that also do not give sharp stock "boundaries".

Discussion

These analyses confirm that West Greenland animals are different from most Canadian stocks, except Grise Fiord in some years, and Creswell Bay in 1993. Beluga samples collected in Creswell Bay in 1996 were different from West Greenland animals, although one of these beluga actually did migrate to West Greenland as determined from satellite tagging. There is nothing in these analyses that rejects the hypothesis that there is a conglomeration of different animals in the summers in the Canadian High Arctic and that they may be hunted as they pass near Grise Fiord and other locations. The proportion of animals sampled in Canada is tiny relative to the total population size, and many areas have not been sampled at all. The time of year in which an animal is sampled should be considered in interpreting the genetic and contaminants data. There is a need to build hypotheses and models based on migration patterns and then to interpret the genetic and contaminant results based on these hypotheses.

The stock structure within West Greenland is equivocal. While evidence from organochlorine signatures (SWG-2001-05) suggests that there is more than one stock wintering in West Greenland, genetic evidence (SWG-2001-06) does not. However it was noted that another genetic analysis (Pålsboll *et al.* in press) had found suggestions of stock structure in West Greenland. The JWG concluded that there was insufficient information to divide West Greenland stocks at present, although there is some indication that such a division may be warranted. It was noted however that division into two or more stocks would result in a lower sustainable yield than that from the single stock situation, and that the conclusion of the JWG was not conservative in this regard.

5.2 Age estimation

SC/9/BN/4 Report of the workshop to determine the deposition rates of growth layers in teeth of Beluga, *Delphinapterus leucas*.

It has been accepted that two Growth Layer Groups (GLGs) form annually in the dentine of beluga teeth since the initial suggestion of Sergeant (1959) that the deposition rate of beluga could be similar to that of sperm whales. Although at that time it was believed that sperm whales deposited two GLGs per year in dentine, this has long since been revised to one per year (IWC, 1969; 1980; Best, 1970; Gambell, 1977). Further investigation of deposition rate in dentine of three captive belugas attempted to resolve any uncertainty (Brodie, 1982; Goren *et al.,* 1987; Heide-Jørgensen *et al.*, 1994). However, none of the results and arguments for two GLGs per year that came from these investigations is unequivocal. The dilemma is thus that it is still uncertain whether one or two GLGs form annually, yet this criterion is essential to the correct interpretation of age from GLGs.

Recently, Hohn and Lockyer (1999), using information on two captive belugas of known history, one with tetracycline antibiotic marking in the teeth, presented new evidence that there is an equally likely deposition rate of one GLG per year, so reopening the question of deposition rate. The most effective agreed way to resolve the matter has been to convene a workshop of experts who are / have worked extensively on the aging of beluga (IWC, 2000; NAMMCO, 2000), to examine teeth from captive beluga that have spent the majority of their lives in captivity and in some cases have received tetracycline antibiotics that would have time-marked the teeth. Teeth from ten such animals were available to the workshop.

Differences among readers generally increased with the number of GLGs in the tooth. For half of the animals, three or four of the readings were close while the other one or two readings were not. For the other half of the samples, the readings ranged widely with no obvious tendency towards agreement. In some cases, this was related to the quality of the tooth section while in other cases the readers were definitely counting different structures as GLGs.

The workshop was not able to reach a consensus on GLGs count for most of the animals so a range of counts was agreed upon during the second day when the individual counts were being compared. These consensus minima and maxima were neither always the extremes of range nor within the range of the original counts by individuals. The ageing working group came to no definite conclusion.

SWG-2001-7 Richard, P. Population dynamics consequence of single growth layer group per year in belugas.
Questions have recently been raised on the validity of the use of two dentinal growth-layer-groups to age belugas. The JCNB Commissioners asked the SWG to consider if using such an assumption might lead to management decisions that are not sustainable. Results of comparisons of age structures that might result from one or two growth layers suggest that the two-growth layer assumption would lead to conservative management decisions.

Discussion
While there was some concern that the deposition of growth layers in captive animals might be different from that in wild beluga, it was noted that this is not the case with other captive toothed whales. It is important to resolve the question of whether beluga deposit 1 or 2 GLGs per year, and the JWG therefore supported the research recommendations in SC/9/BN/4. However, it was noted that the recommendation to administer tetracycline to live-caught and released free-ranging beluga was probably not realistic, as there would be potential human health issues if the beluga were consumed.

The model used in SWG-2001-7 resulted in a change in the instantaneous rate of increase from 3.4% for the 2GLG model to 3.7% for the 1GLG model, a much smaller increase than the group had intuitively anticipated. With the 1GLG model, age of maturity would change from 3 years of age to 6 years of age and adult survivorship would take effect at 2 years of age. Using the 2GLG model, belugas have been aged to 38 years. Under the 1GLG model, beluga would reach the age of 76 years, implying yearly survival of 99%.

The life history parameters that would be implied by the 1GLG model used in SWG-2001-7 raise concern that the assumption of 1 GLG per year may be unrealistic. The JWG agreed that, while there was no definitive proof for either the deposition of 1 or 2 GLGs per year, maintaining the present assumption of 2 GLGs per year would be the more conservative approach and was the recommended approach until definitive evidence for changing the assumption is presented.

5.3 Catches

5.3.1 *Segregation of sexes and age groups in catches*
No new information was presented on sex selection in the catch. Information on the effects of the age structure on the catch on projections of sustainable harvest is presented in Section 5.5.2 (Working Document SC/9/BN/7).

5.3.2 *Struck and loss study in Nunavut*
SWG-2001-8 Ditz, K. Catch statistics for narwhal and beluga in the Eastern Canadian Arctic (1996-2000).
Catch statistics for beluga in the Canadian high Arctic region for the period 1996-2000 are presented. The landed beluga catches are reported by community and are not corrected for under-reporting or killed-but-lost animals. In general, it is believed that the reported harvests for beluga are accurate although there may be under-reporting in some communities. The Canadian communities that are considered to harvest beluga from the high Arctic stock(s) are Qikiqtarjuaq, Clyde River, Pond Inlet, Arctic Bay, Grise Fiord, Resolute Bay, Gjoa Haven, Pelly Bay and Taloyoak. The averaged reported landed catch was 38 beluga per year for the period 1996-2000. The harvest did not change significantly compared with the 1977-1995 average harvest.

There is additional harvesting of beluga in other parts of Nunavut, in Nunavik (northern Quebec) and in the Northwest Territories but hunters in these areas are not believed to be harvesting beluga that from the high Arctic stock(s).

In 1999, a new management system was introduced in Iqaluit and Kimmirut, 2 southeast Baffin communities. Under this new management system, the government-imposed quotas were removed and replaced with a community-based system in which the communities were asked to develop rules and guidelines to ensure the proper management and conservation of the beluga. Hunters were asked to report all the animals that were landed as well as the animals that were killed-but-lost. Beluga that were wounded superficially and which the hunters predicted would survive were reported as "wounded and escaped".

The reported ratio of killed-but-lost to landed beluga was 9% and 11% for the two communities in 1999 and 18% and 7% in 2000. If it is assumed that all whales reported as "Wounded & Escaped" in fact are lethally wounded, these ratios rise to 51% and 16% in 1999 and 18% and 15% in 2000. The reported loss rate results are still preliminary and the reporting system is being reviewed to improve hunters' participation. Effort to collect information on loss rates using different hunting techniques and under various conditions will be made. The results of this study will be used to identify areas where hunting methods can be modified to reduce the loss rate. As more information is collected, the result will be used to correct catch estimate under various conditions.

Discussion

The JWG welcomed these new data on loss rates and encouraged the continued collection of this information. Loss rates are highly variable with hunt type, environmental conditions and hunter skill, and may vary greatly from year to year at the same location. Therefore the application of loss rates to correct past harvest data will have to be done with caution. The JWG noted that the newly reported loss rates were within the range of those found in other studies (Burns and Seaman 1986, Weaver and Walker 1988, Roberge and Dunn 1990) and those used in modelling studies of West Greenland beluga (NAMMCO 2000).

5.4 Abundance

5.4.1 *Re-examination of past aerial surveys*

SC/9/BN/6 Laidre, K.L. and M.P. Heide-Jørgensen. Re-examination of the index estimates of beluga abundance off West Greenland 1981 and 1982.

In 2000, NAMMCO recommended the 1981 and 1982 aerial survey of belugas in West Greenland be re-examined for trend analysis. The original abundance estimates, reported in Heide-Jørgensen *et al.* (1993), did not fit a population model that utilised abundance estimates from surveys in the 1990s and resulted in estimates of population parameters that were inconsistent with beluga life history information. This re-analysis was conducted to verify if the 1981-82 abundance estimates were not results of an error in the original data analysis. In 1981, the revised abundance estimate for all five strata (including all transects) combined (3,045 CV=27) was smaller than that reported for all five strata in Heide-Jørgensen *et al.* (1993) (3,615 CV=33). In 1982, the revised abundance estimate for all five strata (including all transects) (2,209, CV=19) was not different from the estimate reported in Heide-Jørgensen et al. (1993) (2,120, CV=19). In 1981, the pod rate for all strata were 0.087 pods per kilometre (CV=0.30) and in 1982, 0.076 pods per kilometre (CV=0.22). The combined pod rate in the 1998-99 surveys combined was 0.011 pods per kilometre (CV=0.21). In the 1990s, the mean pod size (ranging from 2.4 to 3.3) was about half that of 1981 and 1982. The revised estimates reported here provide an improved abundance estimate for 1981 and 1982.

Discussion

The re-analysis demonstrated that the estimates reported by Heide-Jørgensen *et al.* (1993) were not a result of calculation error, and the revised estimates are close to the originals. However, the JWG noted that there were differences in methodology between the 1981/82 surveys and those conducted in later years, including:

- The plane used in 1981/82 flew faster and lower than the plane used in later surveys.
- The plane used in 1981/82 did not have bubble windows, which resulted in a blind area near the trackline;
- Different observers were used in the earlier surveys.

The first two differences may have decreased the efficiency of the earlier surveys; the last one may have affected in an unknown way.

Although no effect of pod size on sightability was detected in the later surveys, it was noted that pod sizes in 1981/82 were larger on average and included pods outside the size range of those observed in more recent surveys. It was considered likely that these larger pods would have had a higher sightability and that the earlier surveys would therefore have a positive bias compared with those conducted in the 1990's. It was also noted that the estimation of pod size becomes less reliable with larger pods, which may have resulted in a higher degree of error or bias in the earlier surveys.

It was therefore concluded that the surveys conducted in 1981/82 may not be directly comparable to the index surveys conducted in the 1990's. However, the JWG could not rule out that the earlier surveys did in fact reflect actual abundance, so they were used in subsequent population modelling. The JWG considered it unlikely that any further analyses could be carried out to further clarify the issue.

5.5 Ice entrapment events

5.5.1 *Relationship to sea surface temperature*

No information on this topic was presented

5.5.2 *Ice entrapment mortality and its significance for population assessment*

SC/9/BN/7 Alvarez, C. and Heide-Jørgensen, M.P. Alternative perspectives in the assessment of the beluga hunt in West Greenland

This paper addressed the influence of the revised estimates of relative abundance for 1981 and 1982 and the effect of ice entrapments on alternative options for future catch policies in West Greenland. The revised estimates from the 1981 and 1982 surveys from SC/9/BN/6 were included in initial runs of the model. Other variations in the input data included an additional estimate of absolute abundance for the years of 1993-94 and a revision in the catch statistics from 1954 to 1999. In addition, a comparison was made of the results obtained if the assessment is conducted using a logistic model or an age structured model.

The recalculated indices for 1981 or 1982 were not very different from those reported previously. Their inclusion in the model resulted in unrealistically low estimates for the rate of population increase (*Rmax*), as had been found previously (NAMMCO 2001), and they were dropped from subsequent model runs. Results indicated that the uncertainty in model structure have a stronger effect that any other aspect that was investigated. The reason for this result may be due to the uncertainties associated to basic parameters of life history that accumulate within the model and how they interact with the uncertainty associated to the estimates of abundance. Ice entrapment did not have a great impact either in the estimation of population dynamics parameters or the estimation of management parameters after forecasting projections.

The main conclusion of this paper was that results of assessment analyses and the resulting advice depend on the assumptions that are accepted as valid. Because there is not sufficient and satisfactory information on all life history parameters and because an assessment model does not need to include all details of the real population biology, we considered that the current use of a generalised logistic model is appropriate for the definition of alternative catch options. However it is recommended that the performance of specific policies are also evaluated using an age structured model to learn about the consequences of different selectivity patterns in the hunt and the sensitivity of our management tools to variations on the knowledge of life history.

Discussion
While the correction of catch data for past ice entrapment events and the inclusion of ice entrapment events in model projections had a relatively small effect on model predictions, the JWG noted that only historically recorded ice entrapment events had been used to derive their frequency and magnitude, and that these events may be more frequent than recorded in the historical record. Nevertheless it is likely that all events that resulted in harvest were recorded. Therefore it was considered that these events did not have great significance for population assessment.

The age structured model resulted in higher estimates for the maximum rate of increase (*Rmax*) and the maximum sustainable yield rate (MSYR) than the logistic model. However, the finding that the stock is depleted to around 20% of the level in the early 1950s is consistent with other models. The age-structured model predicts a much higher risk of depletion in 10 and 30 years under the harvest scenario considered than the logistic model. However the JWG considered that there were uncertainties in the implementation of this model, and that it required more development. Issues in ageing may affect age structure models and need to be resolved.

5.6 Update of assessment

5.6.1 *Sustainable harvest levels*

SWG-2001-9 Innes, S. Population size and yield of Baffin Bay white whale stocks (*Delphinapterus leucas*). [Presented by Rob Stewart]

Previous analysis of the population size of beluga that migrate from West Greenland to waters adjacent to Somerset Island concluded it had declined by about 62% between 1981 and 1994. This paper used a different statistical approach, Sampling, Importance Resampling (SIR) Bayesian analysis to estimate stock sizes and yields. It uses distributions for various parameters, sampled repeatedly, to produce a distribution of likely estimates. This analysis estimated that the stock size of beluga wintering off West Greenland in 1997 was 5230 (3090-8910, 95% Credibility Interval - CI), about 11% (4-23% CI) of estimated carrying capacity. The estimated decline between 1981 and 1994 was 56%, similar to the 62% previously estimated. Projected to 1999, the model predicted sustainable median landings of about 96 (21 to 271, 95% CI) with a total kill of 160 (27-489, 95%). The stock size estimate for the beluga wintering in the North Water was 23130 (5580-39200, 95% Credibility Interval) but there is no information about the population biology of these whales. The estimated yield for the North Water stock was 584 (36-2105, 95% CI) beluga killed.

Discussion
The JWG considered that the Innes model was useful because it used a methodology and information sources markedly different from those used in other models. Unlike other models, the Innes model used the estimates from the 1996 summer survey in the Canadian High Arctic, and generated an estimate for the stock wintering in the North Water. Most parameter estimates produced, including maximum rate of population increase (R_{max}) and sustainable yield for West Greenland, are consistent with other models considered.

The model also provided estimates of two parameters that have been difficult to determine directly. These are the adjustment factor for the survey index estimates and the number of whales that are killed but not recorded in the catch statistics. The parameter for killed-but-lost and underreporting is higher than killed-but-lost ratios reported and used in other analyses. However, as the parameter incorporates both killed-but-lost and whales that are landed but not reported, this was expected. The posterior distribution of the adjustment factor that converts the index for the surveys off West Greenland to an estimate of absolute abundance had a median of 0.151, somewhat less than the mean of 0.175 which was the correction factor developed empirically for the 1998-99 surveys. However, this adjustment factor also adjusts for whales that were outside of the index survey area, and so does not correspond directly to the empirical survey correction.

The JWG encouraged further development and refinement of this model. A revised survey estimate for the 1996 summer survey is being developed and should be incorporated. The revised survey estimate for the 1998-1999 West Greenland Survey should be used instead of just the 1999 survey.

SC/9/BN/8 Witting, L. On model uncertainty in the assessment of Beluga in West Greenland: Inertia versus traditional density regulated dynamics.
Density regulated models of the beluga off West Greenland have encountered difficulties in explaining the strong downward trend in the time-series of relative abundance estimates. To explain the data, in particular the earlier 1981/82 index estimates, a maximum sustainable yield rate (MSYR) at the lower bound of reality had to be assumed. This study applied an alternative model of inertial dynamics, which is a density-regulated model with superimposed density dependent changes in the intrinsic component of the life history. This model allows for a continuum of dynamics; ranging from the monotonic return to population equilibrium predicted by traditional density-regulated models to cyclic dynamics with damped, stable, and unstable cycles. For the full range of likely MSYRs, the model of inertial dynamics fit the downward trend in the abundance data but this might lead to unrealistic estimates for other parameters in the model.

The management related conclusions are comparable with those of the other models. The inertial model estimates that the current population size is approximately 20% of the expected abundance had the stock not been hunted. The model also estimates that the population can only be expected to recover if total annual removal is reduced to approximately 100 animals.

Discussion
The JWG noted that this model was consistent with other models considered in its estimate of depletion and present sustainable yield. This model therefore does not affect the conclusion that the stock is depleted and that present catches exceed sustainable yield. The fluctuation of life history parameters such as fecundity in the model would however have implications for sustainable yields over the longer term. While the incorporation of inertial dynamics to explain the decline in the index surveys was regarded as a useful approach, it was noted that it would be difficult to gather the data necessary to confirm the mechanisms incorporated in the model. The fit of the model to the index survey series, including the 1981/82 surveys, was not considered sufficient evidence to adopt such a model since the lack of fit of the 1981/82 surveys in other models can be explained by other hypotheses.

5.6.1.1 General discussion of sustainable harvest
Greenlandic hunters had pointed out to the JWG that they believed that belugas had changed in distribution, and were now wintering farther offshore and in areas farther south than in previous years. If this were true, it could explain the apparent decline in the abundance index from 1981/82 to the 1990's. The JWG agreed that while it is conceivable that the apparent depletion of the stock could have been caused by a shift in winter distribution out of the survey area, there is no direct evidence to support this hypothesis.

The distribution of beluga in the core index survey area has not changed over the 18 years surveys have been conducted. The surveys were extended to the south to Paamuit and Kap Farvel in 1998 and 1999, but no additional animals were found in this area. There are no quantitative observations from other sources or surveys to indicate that beluga are occurring in significant numbers outside the survey area. In addition, even if there has been a shift in distribution, it may have been to an area where they are no longer supporting the Greenlandic harvest. The JWG therefore concluded that the substantial depletion observed in the index survey area should not be attributed to a distribution shift unless direct evidence for such a shift is provided.

Hunters noted that although the models predicted extinction at present harvest levels, they would not hunt the stock to extinction. It was not discussed whether this would be due to a voluntary change in hunting behaviour or forced on harvest rates by catch per effort rates too low to support a viable hunt. There was no examination of the capacity of the hunt to detect and kill beluga at very low abundance.

5.6.1.2 General conclusions

All analyses examined agree that the stock is depleted to 20% to 25% of carrying capacity, and that the present sustainable yield is about 100 beluga per year. The JWG supported the conclusions of the NAMMCO Scientific Committee (NAMMCO 2000) that the West Greenland stock is substantially depleted and that present harvests are several times the sustainable yield. The model predicts that if harvests are kept at current level, there is a high risk that it will lead to stock extinction within 20 years. A significant reduction in catch will be required to halt the decline of this stock and allow recovery. The parameters used in the model are presented in Tables 1 and 2.

5.6.1.3 Catch Options

The JWG chose to build on the model used by the NAMMCO Scientific Committee (NAMMCO 2000) to assess the risk associated with various catch options. The JWG concurred that the primary management objective to be addressed should be to arrest the decline of the West Greenland beluga, and that all catch options should be judged against this objective. Further objectives, such as allowing the stock to recover to a specified level within a specified time, can be developed after this primary objective is achieved. It was also decided to present options incorporating a delayed or gradual reduction in catch, since these were considered the most likely options to be adopted.

The model used was the same as that used by the NAMMCO Scientific Committee (NAMMCO 2000) with the following developments:

- The correction for under-reporting and killed-but-loss was estimated for each catch area and year since 1952 and was, on average, 1.2 times the reported landed catch.
- The documented harvest for 1998 was used in the model. The value used for 1999 was still incomplete, but was used.
- Catches were corrected for mortality in ice entrapment, but future ice entrapments were not projected in the model.
- Two additional catch options were considered.

Table 3 shows the probability that the stock size in 2011 will be lower than the stock size in 2001 under the various catch options considered, and Fig. 2 shows the probability distributions of stock trajectory to 2011 under these options. If the management objective is to arrest the decline of beluga numbers, this objective will be met most quickly by ceasing beluga harvesting immediately (Option 6). On the other hand, harvesting at present or higher rates (Option 1) will cause continued stock decline. Management options between these two extremes were also explored including options specifically requested by the Government of Greenland (Option 7 and 8; Table 3).

It is apparent that the total number of beluga killed by hunters must be reduced to about 100 animals per year to have any significant chance of stopping the decline in the stock within the next 10 years. Delay in implementing harvest reductions increases the risk of continued stock decline, as illustrated by the stepwise harvest reduction options (Options 2, 3, 5, 7 and 8). In addition, the stepwise reduction options result in a further decline before the stock begins to recover.

The JWG again emphasised that continued abundance surveys at roughly 5-year intervals will be essential to monitor the progress of the recovery of the stock. An additional abundance estimate will allow greater precision in projecting the stock size, and thus allow managers to adjust catch levels if required to maintain the selected recovery trajectory.

5.6.2 *Review of research requirements*

SC/9/BN/5 Heide-Jørgensen, M.P. A proposal for a renewed effort to determine the stock identity of belugas summering in the Canadian high Arctic.

Despite considerable effort, both satellite tracking and genetic studies have failed to clarify the stock structure of belugas summering in the Canadian high Arctic sufficiently to determine which fraction migrates to West Greenland for wintering and where it concentrates in summer has not been answered. This is of particular concern since the harvest of belugas in West Greenland is the most significant management question for both the JCNB and NAMMCO. This paper presents a proposal for a new effort to elucidate the origin of the large number of whales presently being harvested in West Greenland. It is proposed that a two-year field period should be launched to tag a large number of belugas and to track them through the winter. Areas that have not previously been sampled will be given priority and samples for genetic analyses will be provided as well. The results of the tracking will be used to develop a model for the dispersal of the belugas that can be tested by the genetic studies.

Discussion
The JWG noted that it would be more logical to tag animals in their wintering areas to determine where they go in the summer. However, this has been attempted in Greenland and found to be logistically unfeasible. The JWG therefore supported the work proposed in the working paper SC/9/BN/5.

<u>Ranked Research Recommendations</u>

1. A new abundance and trend estimate (index survey) will be needed in 3 to 5 years. The next survey should include areas to the north of Disko Island and to west of the current index survey area. The survey methods should be identical to previous surveys to facilitate comparison. The use of video for the estimation of correction factors should be continued.
2. The plan for a satellite tagging program with the primary objective of determining the summering area and migratory patterns of West Greenland beluga developed in working paper SC/9/BN/5 should be developed and supported. In addition, beluga diving data should be collected from the West Greenland wintering area in March, for use in estimating correction factors for abundance estimates.
3. Stock delineation efforts using genetic and contaminant analyses should be continued. In particular the contaminant analyses should be re-evaluated to determine if changes in laboratory techniques or sampling methods have influenced the results. The JWG encourages further collection of samples for genetic and contaminant analyses. The availability of skin samples in March from areas north and south of the hiatus in beluga distribution (near 67^o 30’) in the West Greenland index survey area should be determined. If a sufficient number of samples are available, genetic analyses for stock structure should be conducted. Any new informative techniques should be explored.
4. Studies should be conducted to determine whether 1 or 2 growth layer groups (GLGs) are deposited annually in beluga teeth. In this regard the research recommendations in working paper SC/9/BN/4 are supported.

6. NARWHAL

6.1 Stock structure

SWG-2001-10 de March, B.G.E., Maiers, L.D and Tenkula, D. A preliminary analysis of the molecular genetics of narwhal *(Monodon monoceros*) samples collected from Canadian and adjacent waters from 1982-2000.

The molecular genetics of 301 narwhal samples collected from hunts in 9 communities in Canada and 2 locations in Greenland were examined. Other than a weak differentiation of samples from Repulse Bay from Baffin Bay samples, there is little evidence of genetic differentiation among the populations examined. This result may be due to small sample sizes. However, even if sample sizes were increased, there still would be considerable genetic overlap between locations examined. In addition, we believe that genetic differences can be convincingly demonstrated only if they can be shown to persist through time. The results of this study, though, do not necessarily negate the existence of different stocks.

Discussion

It is already apparent that genetics will not be as strong a tool for stock delineation as it has been for beluga. However the JWG encouraged the completion of genetics analyses on the remaining samples as soon as feasible. Dr. Brigitte de March also presented preliminary results that indicated that contaminant analyses may be a more powerful tool for stock delineation of narwhal, and encouraged further work in this area.

SC/9/BN/9 Heide-Jørgensen, M.P., Dietz, R., Laidre, K.L. and Richard, P. Do narwhals from Canada contribute to the harvest in West Greenland?

A model of the dispersal of narwhals in Baffin Bay and adjacent waters is proposed based on a review of recent genetic studies, satellite tracking and compilations of local knowledge. The default definition of a stock or management unit should be based on the assumption that disjunct summering aggregations of narwhals are separate stocks with little or no exchange between whales from other summering grounds. Nine coastal summering concentrations of narwhals, proposed to constitute stocks, are identified. A late fall and an early winter concentrations of narwhals in West Greenland have been tentatively classified as 'aggregations' of unknown stock identity. Hunting of narwhals by Inuit communities in Canada and Greenland will impact the stocks and aggregations on various levels depending on the temporal dispersal of the whales. To assess the sustainability of the harvest in these areas, it is important to identify which stocks and aggregations contribute to which harvest. Nine major hunting grounds in Canada and Greenland are identified and several stocks appear to be harvested at two or more hunting grounds (Fig. 3). Apparently whales from Canadian stocks have a low risk of being taken in West Greenland.

Discussion

The JWG welcomed this synthesis as an important step forward in the stock delineation of Baffin Bay narwhal and determining which stocks are hunted where. Significant questions remain, however. It is still not known which summer aggregation supplies the heavily harvested November aggregation at Uummannaq and winter aggregation in Disko Bay: potential candidates include the East Baffin and Admiralty Inlet summer aggregations. Other summer aggregations, such as Eclipse Sound, Admiralty Inlet and Somerset Island, may be hunted by communities outside of the aggregation areas during their spring and fall migrations. Several aggregation areas, particularly Inglefield Bredning, Admiralty Inlet and the East Baffin, should be a high priority for further satellite tracking work. Additional genetic and contaminants studies may also be useful to further advance the dispersal model for Baffin Bay narwhal.

6.2 Age estimation and life history parameters

No new information on this topic was available to the JWG. In particular, a method for ageing narwhal past the age of maturity is required, and the JWG encouraged research to develop such a method.

6.3 Catches

SC/9/BN/10 Heide-Jørgensen, M.P. Reconstructing catch statistics for narwhals in West Greenland 1862-1999.

Information and statistics including trade statistics on catches of narwhals in West Greenland since 1862 were presented in working paper SC/9/BN/10. Detailed statistics split by narwhal hunting grounds are missing for most of the years. For a future assessment of the sustainability of narwhal catches it is required that: i) statistics are broken down by municipalities and in some cases by settlements to allow pooling by hunting grounds, ii) statistics are corrected for underreporting, and iii) that correction factors are applied for different hunting situations.

Discussion

The JWG welcomed this information and encouraged Heide-Jørgensen to further develop the compilation. However, it was recognised that catch records are highly inaccurate for some time periods and it may prove impossible to retrieve a complete catch history. The Piniarneq catch reporting system began in 1993, and since then catch records have been more complete. The JWG noted with concern that records of the trade in maktak indicate that catch records for Qaanaaq, Upernavik and Uummannaq are incomplete by a substantial margin, and recommended that reporting be improved in these areas.

Landed catches of narwhal were presented for several communities in the Canadian Eastern Arctic in working document SWG-2001-8 (see Section 5.3). These reports do not include corrections for underreporting or killed-but-lost whales. Underreporting of narwhal catches is likely not a large problem for Canadian communities, since most communities hunt under a tag/licensing system. However it is possible there was some underreporting of female narwhal in the catch.

The average yearly reported landed catches for the period 1996-2000 is 364 for Baffin Region communities. Narwhal harvest in Nunavut has increased in recent years. There is additional harvesting of narwhal in other parts of Nunavut (Hudson Bay communities) but they are not believed to be harvesting narwhal from the Baffin Bay population.

6.4 Struck and loss Study in Canada

The program for collecting information on the proportion of narwhal that are killed-but-lost, or wounded but lost from Canadian narwhal hunting communities described in SWG-2001-8 (see section 5.3.1) has begun to provide valuable information on these important parameters. The reported ratio of killed-but-loss to landed narwhal is between 6% and 31% for 4 communities in 1999 and 2000. These ratios rise to between 19% and 86% if it is assumed that all narwhal reported as "wounded & escaped" are in fact lethally wounded. The ratios of killed-but-lost to landed narwhal reported in this study are similar to the ranges that have been reported in previous studies. However the program is at an early stage and is ultimately directed in reducing losses. The data require additional analyses to show the loss rates in various types of hunts using different methods. The JWG strongly encouraged the continued collection and analysis of this information. Care should be taken in using the results to correct total removal from historic harvest, as historical changes in hunting practices and the management regime for narwhal could be expected to affect loss rates.

6.5 Abundance

No new abundance estimates for narwhal were presented.

6.5.1 *Review of survey plans*

SC/9/BN/11: Laidre, K.L., Heide-Jørgensen, M.P. and Dietz, R. Diving behaviour of narwhals (*Monodon monoceros*) in the Canadian Arctic determined by Time Depth Recorders (TDRs).

In August 1999 and 2000, four suction cup attached TDRs were deployed and retrieved from free ranging narwhals in Tremblay Sound, Baffin Island and Creswell Bay, Somerset Island, Canada. The TDRs were attached to a flotation device consisting of three oval net buoys held together with 6mm nylon pins, made to withstand pressure at over 400 m. The tags remained on the whales for between 12 and 33 hours. The two whales tagged in Tremblay Sound exhibited clear differences in diving behaviour, which could not be attributed to sex or body size, as both whales were males of similar size and length. In Tremblay Sound, narwhal 1 made longer, deeper dives (mean depth = 50.8 m, mean duration = 4.93 min) and spent less time at the surface than narwhal 2 (mean depth = 20.3, mean duration = 2.55 min). In Creswell Bay, the two narwhals (3 and 4) had similar diving behaviour. Both whales generally made short, shallow dives (mean depths = 20.75 m and 34.4 m, mean duration = 3.35 min and 4.26 min), especially when compared to the whales tagged in Tremblay Sound, which had dove at depths and for duration almost twice those in Creswell Bay. The percentage of time spent within specific depth bins was calculated for both narwhals tagged in Tremblay Sound. Only these two tags provided the resolution necessary for this analysis. In Tremblay Sound, narwhals 1 and 2 spent 30.3% and 52.9% of their time in depths < 5 m. These data are fairly consistent with other studies. Correction factors to 5 m depths, generally applied to aerial survey data to account for whales that are below depths at which they can be counted from the air, were calculated as 3.3 and 1.9.

Discussion
The JWG found this information useful and recommended that TDR deployments should continue in conjunction with other tagging projects. It can be expected that diving activities will be site-specific and related to bathymetry and the activities of the animals. It was considered likely that there was a period of time after the initial deployment when the disturbance of the animal from the tagging process would render the diving data unreliable for the calculation of correction factors, and this initial period should be detected and removed from the analysis. It was also considered useful to have simultaneous monitoring from both TDRs and satellite-linked TDRs on the same animal, in order to calibrate and ground-truth the diving data received from satellite-linked TDRs.

SWG-2001-11: Richard, P.R., Proposal for winter or summer surveys of Baffin Bay narwhals
Narwhals from the "Baffin Bay population" winter throughout Baffin Bay and Davis Strait and summer in several aggregation areas in Northwest Greenland, along Baffin Island and in the Arctic archipelago. Population estimates are hampered by low precision due to the aggregated distribution of narwhals and are biased by lack of coverage of their complete range in both summer and winter surveys. It was proposed that future surveys use adaptive sampling designs in areas of aggregation to increase survey precision and that the range of surveys be extended to cover more of the seasonal range of narwhals to assess fully their numbers.

Discussion
In considering the technical aspects of the proposal, the JWG noted that the adaptive framework was a promising avenue towards obtaining more precise and reliable survey estimates. The cost of the survey could be quite high depending on the level of coverage chosen, however it should be feasible to conduct the survey over 2 to 3 years. The JWG noted that digital cameras were to be used in surveys for narwhal in Greenland (see below), and recommended that this technology be considered for the Canadian surveys if it proves successful in Greenland.

Heide-Jørgensen updated the JWG on surveys to be carried out in August 2001 in Greenland. The summer aggregations around Qaanaaq and Melville Bay will be surveyed using a plane equipped with 2 digital cameras. In addition to abundance estimates using strip transect methods, it will be possible to sex and measure subsamples of narwhal. Some individuals will be photographed at closer range, and animals with visible marks will be used to provide separate mark-recapture estimates of abundance and information on movement in the areas.

Priorities for surveys
The JWG noted that narwhal have an extensive distribution in summer and winter, and that areas should therefore be prioritised in order to provide some guidance as to the urgency of surveys and the allocation of survey effort. In general, it was considered that surveys of the summer aggregation areas were of greater value than surveys of the wintering areas in Baffin Bay, as it is difficult to assign the latter aggregations to hunting areas (see Section 6.1). Survey effort should be concentrated on summer aggregations that are hunted in the aggregation area or during migrations. In addition a higher priority should be given to areas that have not been surveyed recently, or that have never been surveyed. This suggests that the following summer aggregation areas should be of highest priority for surveys: Inglefield Bredning, Melville Bay, Admiralty Inlet, Eclipse Sound and East Baffin aggregations. It was also considered of high priority to survey the Uummannaq fall aggregation as this group supports high takes in some years. The Smith Sound, Jones Sound, Somerset Island and Parry Island areas were considered of lesser priority primarily because

they probably support less hunting. However the JWG noted that it would be preferable to cover all areas in the Canadian Arctic rather than surveying only high priority areas.

The JWG considered that the best way to proceed was to establish a subcommittee to plan, conduct, and analyse a survey in the Canadian High Arctic, as had been done for beluga in the past. The subcommittee should further develop the prioritisation scheme outlined here and provide a cost plan for a survey for the consideration of the JWG.

6.6 Assessment and research recommendations

The quality of narwhal assessment would be improved by a number of research activities

Catch Statistics

- Improve the collection of current harvest statistics, including information on loss rates. Loss rate may be significant in some areas and times, and all population removals must be considered in stock assessment.
- Review historical harvest statistics, providing, to the extent possible, corrections for underreporting and killed-but-lost animals.

Stock identity

- Sampling should be continued in hunting areas and genetic and contaminant analyses should be pursued.
- Satellite tracking experiments should be conducted from all aggregation areas, to determine if significant mixing between aggregation areas occurs, and to identify migration routes and wintering areas.
- Other methods of stock delineation should be investigated.

Abundance

- Abundance surveys should be carried out in summer concentration areas in Canada and Greenland. The technical aspects of the surveys should be developed by a subcommittee of the JWG.
- The deployment of TDRs and satellite-linked TDRs should be continued to provide data to correct surveys for diving animals.

Life history

- Methods for ageing narwhal should be developed and tested.

6.6.2 Sustainable harvest levels

Recommendations on the sustainable harvest of narwhal for Canada and West Greenland could not be produced at this meeting. Narwhal harvests have increased in some areas of Canada and Greenland over the past 10 years. Further increases might be expected in Greenland if hunters switch from beluga to narwhal in the case where restrictions are implemented on beluga harvest, and in Canada if quotas are removed. New information on narwhal stock structure from tagging and genetic studies suggests that there are several stocks, some of which might be susceptible to overexploitation. The JWG suggested that this was cause for some concern, as there was insufficient information available to assess whether such harvest increases were sustainable. The JWG therefore considered that the assessment of narwhal stocks should assume a much higher priority in the coming years.

6.6.3 Schedule for assessment

If the planned summer surveys for Inglefield Bredning and Melville Bay are successfully completed in summer 2001, there should be sufficient information to complete an assessment for these stocks by 2002. The JWG considered that the assessment of stocks summering in Canada is also a priority and should be completed as soon as feasible.

7. OTHER SOURCES OF INFORMATION

7.1 Local knowledge

7.1.1 *Meeting between Greenlandic/Canadian Hunters and the JWG*

The JWG met twice with the hunters from Greenland and Canada. During the first meeting, the hunters from each country made a presentation. A review of traditional knowledge studies that have been conducted in Canada was also presented (Working Paper SWG-2001.12) along with information on the procedure for changes to hunting regulations currently underway in Greenland. This was followed by discussions on the presentations.

The hunters were asked to consider the same questions posed to the JWG by NAMMCO and JCNB and to provide feedback on those questions. The hunters from both countries met together to discuss these questions. The JWG met again with the hunters to discuss their responses to the questions posed by NAMMCO and JCNB, and to have some general discussions on beluga and narwhal. While the Greenlandic hunters left on Friday morning, the Canadian hunters remained and participated in other parts of the meeting of the JWG. The list of hunters that participated at this meeting is presented in Appendix 1.

7.1.1.1 Greenlandic Hunters

The Greenlandic hunters had been asked by the Greenland delegation to review the "Hvidbog om Hvidhvaler" and provide comments on that for this meeting. The Hvidbog om Hvidhvaler (Rydahl and Heide-Jørgensen 2001) is a publication produced by the Greenland Institute of Natural Resources that summarised the information available on beluga. The presentation from the Greenlandic hunters focused on points of disagreement between their knowledge and what was presented in Hvidbog om Hvidhvaler. Their presentation included:

- **Breeding frequency and gestation period.** The hunters reported that they believe that beluga are pregnant for one year, and calve every year. As support for this, they report observing many female beluga that were both pregnant and accompanied calves. Female beluga have also been seen with the tail flukes of a newborn already outside their body and accompanied by a calf. Herds of beluga are also seen to contain calves of various ages, i.e. individuals that are various colours of grey.
- **Time of breeding.** Hunters believe that beluga may mate at all times of the year, even in winter. In the Avanersuaq/Thule Region, mating may occur in March, as well as in winter and summer. In Central West Greenland, female beluga tend to have foetuses in May and June. In Northern Greenland – the Upernavik region – beluga have larger calves.
- **Sexual maturity.** Hunters believe the beluga mature at 3 to 4 years of age. By this time the beluga are a fairly large size and the hunters believe they are therefore sexually mature and able to breed, as do other mammals at this stage.
- **Migration patterns.** Hunters believe that migration patterns are very variable. Beluga have started to migrate to the southern regions of Greenland and have been spotted near Nuuk and further south. Hunters believe that the beluga have moved from Vaigat Strait in May and June to the area off Disko Bay and they believe this is due to the increased traffic in Vaigat Strait. The hunters believe that noise can be disruptive to the migration of beluga, and that the whales can be scared from their feeding grounds, and may not return to those areas. However, in some areas the beluga appear to get used to the noise
- **Stock size.** The hunters believe that if the stocks were depleted, they would be catching fewer beluga, and this is not happening.

On behalf of Leif Fontaine, Chairman of the Organisation of Fishermen and Hunters in Greenland, a prepared letter was presented by Jeremias Jensen with respect to the inquiry into a stricter management of beluga and narwhal that is currently being undertaken by the Greenland Department of Industry. The organisation fully agreed that there is a need for regulation of harvesting practices in Greenland, and did not object to separate management practices for beluga and narwhal. However, they stressed that this must be done in consultation with the users. They would like to see surveys conducted at close range, not just by airplane, and investigations of other factors including migration patterns. They would like to see these investigations over a longer period of time prior to major changes in the management system. They hope to work with biologists to find answers.

7.1.1.2 Canadian Hunters

The two hunters from Canada came from Pangnirtung, on southeast Baffin Island and Grise Fiord, at the southern tip of Ellesmere Island. Jooeelee Papatsie from Pangnirtung, shared his thoughts and understanding on the behaviour of beluga and narwhal in the Canadian arctic. Jooeelee reported that there is a separate stock of beluga in Clearwater Fiord, where they calve all through the summer. Hunters do not harvest from there. Clearwater Fiord is located near the end of Cumberland Sound. A different stock, which does not go to the Clearwater Fiord area also comes to the Pangnirtung area. In April, these beluga arrive at the floe edge in Cumberland Sound. These are smaller beluga than those that enter Clearwater Fiord and tend to stay in Cumberland Sound. Their maktak is softer and tastes different.

Jooeelee also noted that elders have reported seeing whales in regions where scientists claim there are none, so he believes there are animals in these regions, such as in the vicinity of Wakeham Island in Cumberland Sound. He would like to invite the scientists to come and conduct surveys together with Inuit on beluga whales.

The satellite tagging done recently is in conformity with the knowledge of the Inuit on the migration patterns. As with the Greenlandic hunters, Jooeelee notes that the animals breed in different patterns than scientists say, and pregnant beluga may also have young with them. They can get pregnant again while they still have a calf. Pollution is also a problem for the whales and this is why it is harder to catch whales in recent times. While hunters used to be able to catch the animals year round, the quotas now mean that people rush to get animals before the quota is gone. Hunters and biologists need to work together to solve this. Hunters and biologists must share knowledge with each other so that both can benefit.

Jooeelee noted that 3 different types of narwhal are seen at Pangnirtung: smaller ones, the larger ones that are whiter and a blacker one. These blacker ones are further offshore. Hunters butcher the animals and know the different types when they find them. While the animals eat squid before they enter Cumberland Sound they switch to eating Greenland halibut in Cumberland Sound.

Larry Audlaluk from Grise Fiord in Nunavut also provided some comments on his knowledge of beluga and narwhal. He noted that in the high Arctic, the beluga and narwhal are very familiar to people. Beluga are present year round near Grise Fiord. The beluga that are present in the winter are small in size, while those that come in summer are larger in size.

Narwhal are also known to Grise Fiord people and they believe they do not share same stock with Pond Inlet. The pattern of movement of narwhals past Grise Fiord depends on how the ice melts. When the ice goes out in the spring, if the Ellesmere Island side opens first, then the narwhals will go to Grise Fiord, but if the ice opens first near Devon Island they tend to stay on that side of Jones Sound, and do not go to Grise Fiord. In some years they arrive early in Grise Fiord while at other times, they do not show up. Larry noted that the community would like to see research conducted on the narwhals that come by their community. Larry reported that the narwhals come from different areas and do not always come from the same stocks and he believes that the narwhals in Grise Fiord and Qaanaaq are not from the same stock. Sometimes narwhal arrive that behave differently than normal – much more shy. There are enough whales and Inuit harvest them only to meet their needs. While Inuit used to harvest more animals, there are now fewer dogs and therefore fewer narwhal are harvested.

As Jooeelee noted, Larry hoped that scientists would also learn from the people. It is easy to understand that those who are striving to acquire knowledge don't always want to listen to traditional knowledge and this hurts the Inuit. Larry believes that people notice what Inuit do today because of the actions of the commercial whalers in the past, not because of the action of the Inuit themselves.

7.1.1.3 Summary of Canadian Traditional Knowledge Studies

SWG-2001-12 D.B. Stewart. Inuit Knowledge of beluga and narwhal in the Canadian Eastern Arctic [presented by K. Ditz].

This report summarised three traditional knowledge studies of beluga and narwhal in the Eastern Canadian Arctic. Because of differences in study designs, it was not possible to clearly differentiate between knowledge and opinion about beluga and narwhal behaviour. The behaviour and distribution patterns of beluga and narwhal were described for the 6 Inuit seasons, which are based on environmental conditions:

- Ukiu (equivalent to winter, early January – mid-March) – period of extensive sea ice which continues to thicken and coalesce, snow on the land and ice, short periods of daylight getting longer, and very cold.
- Upingaaksak (equivalent to early spring, mid-March – late May) – period of maximum ice cover and ice thickness, snow on the land and ice, long daylight period getting longer.
- Upingaa (equivalent to late spring, late May – mid-July) – period of progressive snow melt, widening of ice leads and disappearance of ice, 24 hours daylight.
- Auja (equivalent to summer, mid-July – early September) – period of open water with some drifting pack ice, daylight period long but decreasing.
- Ukiaksak (equivalent to early fall, early September – late October) – period of open water with ice beginning to form late in the season along the shoreline, snow on the land and ice on the lakes, daylight period short and decreasing.
- Ukiak (equivalent to late fall, late October – early January) – period when new ice hardens and thickens to form extensive areas of landfast or drifting pack ice, snow on the land and ice, near 24 hour darkness.

In many cases the lack of observation of beluga and narwhal in an area is due more to hunters not being present in those areas, rather than to a true absence of the animals from that area. The two major reasons for this would be proximity to a community and season (i.e. periods of little or no daylight).

For beluga, ukiu is a period of ice entrapments, especially in Fury and Hecla Strait and Queen Anne's Strait. In upingaaksak, there are more observations, especially feeding at the floe edge near southeast Baffin Island communities and movement is reported northward past Qikiqtarjuaq. Beluga are also widespread but sparsely distributed around north Baffin Island, and are moving north near Ellesmere Island. In upingaa, beluga move through Hudson Strait, going northwest past Kimmirut, while those in Frobisher Bay and Cumberland Sound are around the floe edge, moving up the west coast of each as ice recedes inland. Elsewhere on Baffin, they continue to migrate northwards and enter fiords and inlets as the ice melts. Some beluga congregate at the floe edge in Lancaster Sound waiting for ice break up to allow continuation into Barrow Straight and Peel Sound whereas others continue from Lancaster Sound south into Prince Regent Inlet. In northern Foxe Basin they are observed moving northwards. In auja there are few sightings near Iqaluit and Kimmirut, while near Pangnirtung there is large-scale calving in Clearwater Fiord. Calving is also reported in the Clyde River area and Milne Inlet. There are few beluga near Pond Inlet in auja. Beluga are seen near Grise Fiord and are moving north near Igloolik and Hall Beach in Foxe Basin. In ukiaksak beluga are migrating south past Kimmirut and moving out of the bays near Pangnirtung and Iqaluit. Most are females with young, or juveniles. On north Baffin, they are moving out of Admiralty Inlet and east out of Jones Sound near Grise Fiord. In ukia, there are no sightings reported from south Baffin, while on north Baffin they continue to move out of Admiralty Inlet. In northern Foxe Basin there is southward movement past Hall Beach.

Some communities, particularly in the Southeast Baffin area, report a decrease in the numbers of beluga. Pangnirtung reports fewer beluga than historically, but believe the population has stabilised and is now increasing. Iqaluit respondents report seeing smaller groups. Changes in migration pattern and changes in ice conditions are reported and an avoidance of areas where engine noises are present has been noted. Only one large-scale calving area is reported - Clearwater Fiord in auja. Food items include cod year-round, turbot at the floe edge and in the bays, anadromous char in fall, along with other fish in some locations and also shrimp. Ice entrapment is widespread but infrequent, reoccurring in some areas. For three years after one ice entrapment reported near Grise Fiord no whales were seen in the area. Predators are believed to include Greenland shark and polar bears although observations of successful predation are limited. All the southeast Baffin communities report differences (some seasonal) in the appearance of the beluga near their communities and believe this is indicative of different stocks. However, the northern communities did not report seasonal differences in beluga.

For narwhal, in ukiu, large breathing holes are reported at the floe edge near Qikiqtarjuaq and narwhal may overwinter there. In upingaaksak, narwhal are at the floe edge and moving north. In upingoa, narwhal continue to move north and are seen at the ice edge near Grise Fiord. Some whales congregate at the floe edge in Lancaster Sound waiting for ice break up to allow continuation into Barrow Straight and Peel Sound whereas others continue from Lancaster Sound south into Prince Regent Inlet. In auja narwhal are found in the fiords on east Baffin Island and in Admiralty Inlet and are seen moving both east and west through Fury and Hecla Strait. In ukiaksak there is migration out of the fiords and southwards and there are fewer animals than in auja. In ukia, narwhal are occasionally seen in the Igloolik area and Pond Inlet, and are moving out of the bays and southwards.

Hunters generally report that the narwhal population increased in the 1960s and 1970s, but the distribution of the narwhals has changed, which they attribute to the noise from shipping and other activities and earlier break up of the ice. Calving is believed to occur in fiords, inlets and sounds where the animals feed. Narwhal feed on a variety of fishes and invertebrates, with few discrete feeding areas. Ice entrapment is infrequent and predators include killer whales, polar bears and sharks. Clyde River and Resolute Bay hunters identified two varieties of narwhal based on appearance, while Grise Fiord identified two different stocks based on behaviour. Other communities did not identify the occurrence of different stocks.

7.1.1.4 General Discussion

These presentations were followed by a general discussion among the hunters and members of the JWG. Greenlandic hunters reaffirmed that they too are interested in a sustainable harvest of beluga, and they want to work with scientists. They want to see decisions made based on real information, and not on assumptions. The hunters also wanted to have confidence in how the studies are conducted and that they will provide accurate results.

They do not believe that beluga give birth to young only every 3 years and they believe that beluga may give birth at just about any time of the year, as evidenced by the capture of 5 pregnant beluga last February along with one beluga with a calf. The hunters believed that they would never hunt whales to extinction. Rather they are concerned that other factors such as pollution might cause the whales' extinction. Changes have been noted in the fat of beluga and perhaps this has something to do with pollution.

Hunters noted that it is very important for the scientific community to explain what it is they are doing in the community closest to where they are doing the work. It was felt that some of the questions would not be asked if the communication was better. Hunters are also always curious on whether the methods are improving, for instance tagging and tranquillising, for all species and all methods. There was concern over the effect tagging may have on the normal movements of the whales and on their survival. Scientists noted that they have re-captured and re-sighted tagged animals up to 11 months after tagging and they have continued to look healthy.

The meeting adjourned and the next day the hunters from both countries met together to discuss issues of common concern and their responses to the questions posed by NAMMCO and the JCNB for the JWG to address. The hunters met again with the JWG members to discuss their responses to the questions.

In summary, the responses to the questions posed by the JCNB were that:

- Current hunting practices should be maintained and quotas removed.
- Both Canadian and Greenlandic hunters believe they harvest local stocks, but that there can be some exchange between stocks.
- Narwhal parameters are not accurate because they don't use hunters' knowledge.
- Using teeth to age the beluga is not adequate; they would like to see more effective methods. They believe that beluga reproduce annually.
- Stocks are not shared because Canadian and Greenlandic hunters harvest at the same time of year.

In summary, the responses to the questions posed by NAMMCO were that:

- Ice entrapments are part of the natural cycle of the population.
- Warmer air and sea conditions will lead to less ice entrapment events.
- Hunters must be consulted before surveys are undertaken.
- Some of the questions had to be answered by the biologists.

The issue of the frequency with which beluga and narwhal give birth was raised again. The hunters reiterated their belief that based on their observations of both species; calves could be born every year and could be born at different times of the year. JWG members explained how scientists had come to the conclusion that females had a calf every 3 years, noting that their work had shown that, on average, about one in three females was nursing or about to give birth. It was explained that this does not mean that a female cannot reproduce more often, but that this is an average number. This is based on information gathered in many areas across the arctic from the whales landed by hunters. It was suggested that the differences between the hunters and the JWG members resulted from differences in the interpretation of the same observations, and that the scientists did not disbelieve the hunters' observations. It was agreed that the hunters and scientists needed to work together to address this and other issues.

Hunters also reiterated concerns about decisions being made that affect their livelihood based on assumptions. The hunters indicated that they would like to work with scientists to ensure that surveys and studies are conducted in representative areas. It was stated by the hunters that if scientists had worked with them from the start, perhaps money and time could have been saved and some of these issues that face us today could have been avoided.

The meeting concluded with an agreement that the consideration of traditional knowledge from hunters is important to assist the scientists in doing their work and to help the managers in their work. JWG members have worked with the hunters of various communities in the past and will continue to do so in the future. However, it was believed that this meeting had been an important step in developing the relationship between hunters and scientists and that the lines of communication between the two groups should be kept open and active.

When the JWG discussed the input of the hunters later in the meeting, it was agreed that an agenda for discussing the issues raised by hunters during this meeting, and other issues that may arise, should be developed in consultation with the hunters. It was suggested that the issue of birth rates might be well suited as the lead issue on the agenda, given the prominence this issue had in the discussions with the hunters. It is believed that with continued dialogue and communication a better understanding of each group's point of view can be achieved.

7.2 Incidental sightings from other sources

The JWG noted that other activities being conducted in Davis Strait and Baffin Bay, such as surveys for other animals, oil exploration and fishing, might provide the opportunity for the collection of opportunistic sightings of beluga and narwhal in areas and in seasons that have not been surveyed recently. This might be useful in detecting unknown concentrations and/or distribution shifts of narwhal and beluga in the area. The JWG suggested that contacts should be established with people working in these areas, and that they be asked to record the extent of their travels in the area and the locations where beluga or narwhal were seen. If a larger scale project that has good potential for collecting reliable sightings of beluga or narwhal (such as a polar bear survey) is to be conducted in the area, a more formal method of data collection should be established.

8. OTHER BUSINESS

There was no other business.

9. ADOPTION OF REPORT

A draft version of the report containing all major sections was adopted on May 13, 2001.

10. REREFERENCES CITED

Best, P. 1970. The sperm whale *(Physeter catodon)* off the west coast of South Africa. 5. Age, growth and mortality. *Investl Rep. Div. Sea fish. S.Afr.*79:1-27.

Brodie, P.F. 1982. The beluga *(Delphinapterus leucas)*: Growth at age based on a captive specimen and a discussion of factors affecting natural mortality estimates. *Rep. Int. Whal. Commn* 32:445-447.

Burns, J.J. and Seaman, G.A. 1986. Investigations of belukha whales in western and northern Alaska. II. Biology and ecology. Report by Alaska Department of Fish and Game, 1300 College Road, Fairbanks, Alaska 99701. 129 pp.

Gambell, 1977. Dentinal layer formation in sperm whale teeth, pp.583-590. *In,* M.Angel (ed.), *A Voyage of Discovery,* Pergamon Press, Oxford, 696pp.

Goren, A.D., Brodie, P.F., Spotte, S., Ray, G.C., Kaufman, H.W., Gwinnett, A.J., Sciubba, J.J. and Buck, J.D. 1987. Growth layer groups in (GLGs) in the teeth of an adult belukha whale *(Delphinapterus leucas)* of known age: evidence for two annual layers. *Marine Mammal Science* 3:14-21.

Heide-Jørgensen, M. P., H. Lassen, J. Teilmann and R. A. Davis. 1993. An index of the relative abundance of wintering belugas *(Delphinapterus leucas*) and narwhals (*Monodon monoceros*) off West Greenland. Can. J. Fish. Aquat. Sci. 50:2323-2335.

Heide-Jørgensen, M. P. and J. Teilmann. 1994. Growth, reproduction, age structure and feeding habits of white whales (*Delphinapterus leucas*) in West Greenland waters. Meddr Grønland, Biosci. 39: 195-212

Heide-Jorgensen, Jensen, J., Larsen, A.H., Teilmann, J. and Neurohr, B. 1994. Age estimation in white whales *(Delphinapterus leucas)* from Greenland. *Meddelelser om Gronland, Bioscience* 39:187-193.

Hohn, A. and Lockyer, C. 1999. Growth layer patterns in teeth from two known-history beluga whales: reconsideration of deposition rates. Paper submitted to the IWC Scientific Committee, Grenada, May 1999, IWC/SC/51/SM4.

[IWC] International Whaling Commission. 1969. Report of the meeting on age determination of whales. *Rep. Int. Whal. Commn* 19:131-137.

[IWC] International Whaling Commission. 1980. Age determination of toothed whales and sirenians. *Rep. Int. Whal. Commn* (Special Issue 3):1-50.

[IWC] International Whaling Commission. 2000. Report of the sub-committee on small cetaceans. *J. Cetacean Res. Manage.* 2 (Suppl.): Annex I, p. 247-248.

[NAMMCO] North Atlantic Marine Mammal Commission. 2000. Report of the NAMMCO Scientific Committee working group on the population status of narwhal and beluga in the North Atlantic. In: NAMMCO Annual Report 2000, NAMMCO, Tromsø, Norway, in press.

Pålsøll, P.J, Heide-Jørgensen, M.P. and Berube, M. In press. Analysis of mitochondrial control region nucleotide sequences from Baffin Bay white whale, *Delphinapterus leucas*: detecting pods or subpopulations. *NAMMCO Sci. Publ.*5.

Roberge, M.M. and Dunn, J.B. 1990. Assessment of the subsistence harvest and biology of narwhal (*Monodon monoceros*) from Admiralty Inlet, Baffin Island, N.W.T., 1983 and 1986-89. *Can. Tech. Rep. Fish. Aquat. Sci.* 1747, 32.pp.

Rydahl, K. and M.P. Heide-Jørgensen. 2001. Hvidbog om hvidhvaler. Rapport til fangerne i Grønland om den videnskabelige viden om hvidhvaler. Telnisk rapport nr. 35. Pinngortitaleriffik, Grønlands Naturinstitut, Nuuk.

Sergeant, D.E. 1959. Age determination in odontocete whales from dentinal growth layers. *Norsk Hvalfangsttid.* 48(6):273-288.

Weaver, P.A. and Walker, R.S. 1988. The narwhal (*Monodon monoceros*) harvest in Pond Inlet, Northwest Territories: hunt documentation and biological sampling, 1982-1983. *Can. Manus. Rep. Fish. Aquat. Sci.* 1975: 26 pp.

Table 1. Boundaries for prior distributions of parameters estimated from data

	Lower	Upper
Juvenile Survivorship	0.5	0.9
Adult Survivorship	0.9	0.999
Original Population Size	4915	984609
Index Rescaling Parameter	0.01	2

Table 2. Parameters values assumed known in age structured model.

Age at Sexual Maturity	4
Calving Interval	3
Age Early Risk Over	2
Siler Parameter	1
Siler Parameter	0.35
Age Late Risk Starts	40
Shaping Parameter	3

Table 3: Probability that the abundance of West Greenland beluga will be lower in 2011 than in 2001 under various catch options. Eight options for future catches are provided for the period from 2001 through 2011. The probabilities are given in the range from 0 to 1 where 0 is no probability of a decline and 1 is certainty that the population will be lower in 2011. The population trajectories are presented for a 10-year projection. The model in use is Logistic, including the abundance in 1993 and removal of the ice entrapment effect in the catch for the estimation. No ice entrapments are assumed to occur in the projections.

Option	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007-2011**	**Probability**
1	700	700	700	700	700	700	700	0.95
2	500	300	300	300	300	300	300	0.59
3	500	300	150	100	100	100	100	0.33
4	100	100	100	100	100	100	100	0.20
5	700	700	500	300	150	100	100	0.57
6	0	0	0	0	0	0	0	0.00
7	400	300	150	100	100	100	100	0.31
8	400	200	100	100	100	100	100	0.28

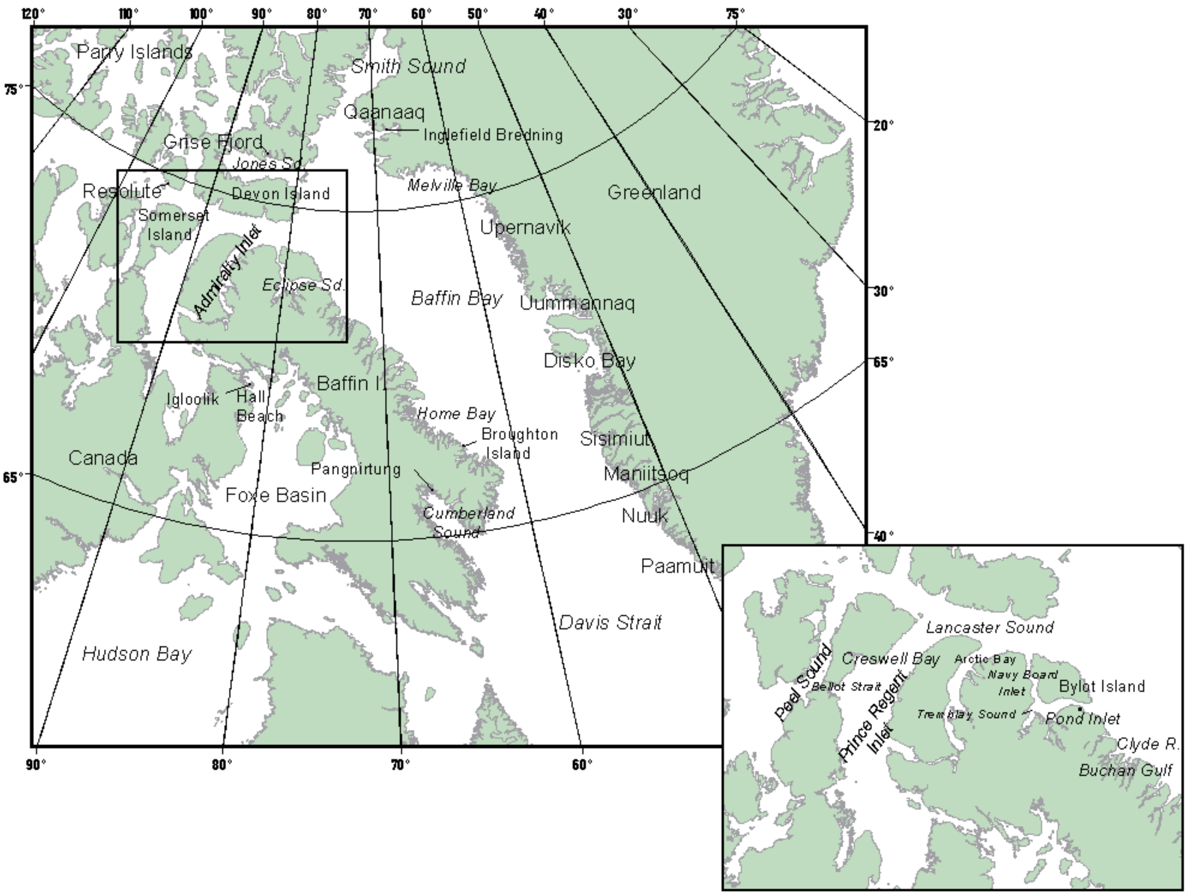

Fig. 1. Map of the Canadian eastern Arctic and of Western Greenland localities mentioned in the report. (from SC/9/BN/9).

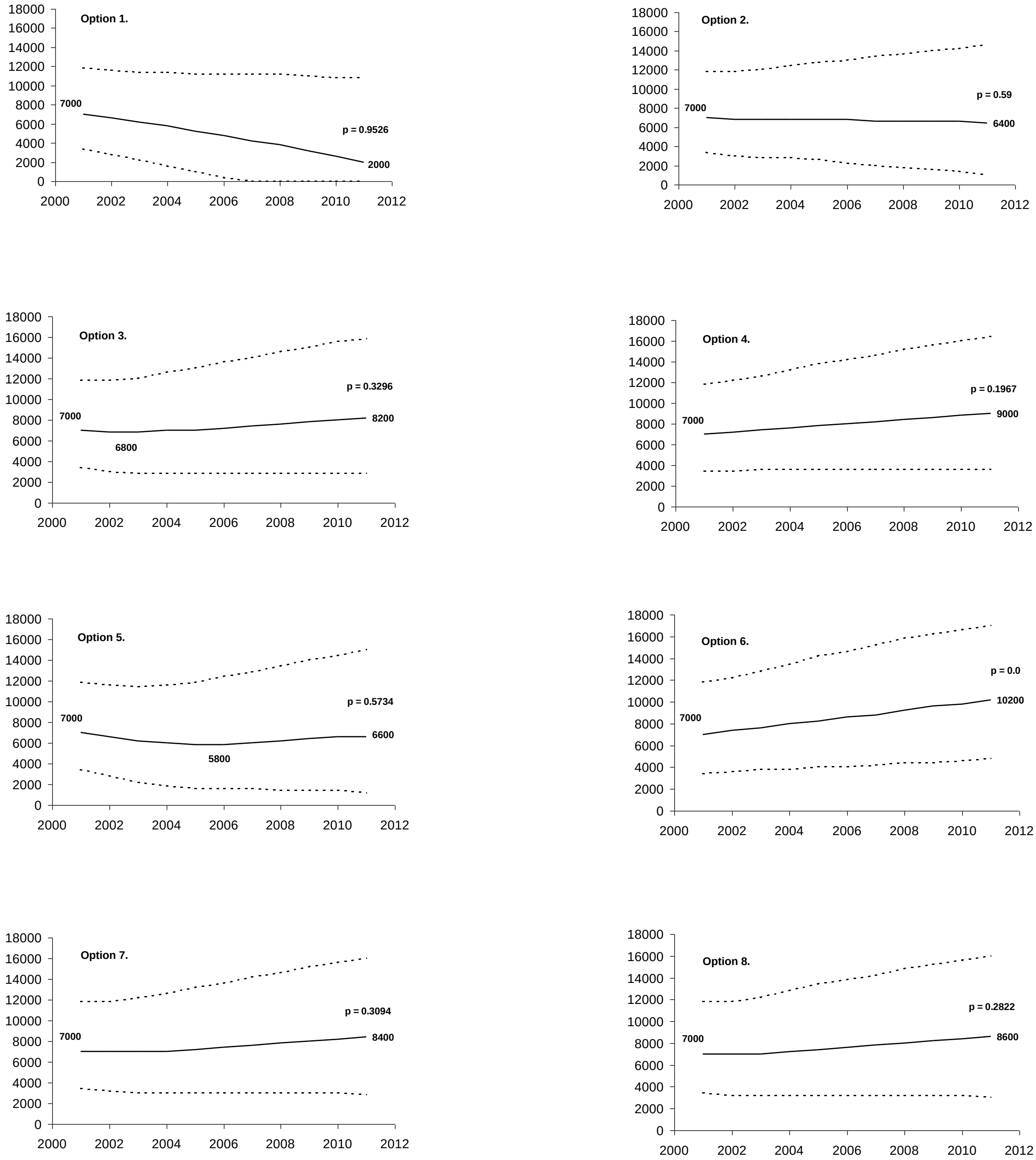

Fig. 2. Predicted trajectories for the beluga population off West Greenland obtained after applying eight different harvest schedules. Solid lines represent the 50th percentile of the Bayesian posterior distribution; broken lines represent the 5th and 95th percentiles. Also shown are the initial and final values, if the lowest population level is not one of them, then it is shown separately. P values represent the maximum probability of decline from year 2001 to year 2011.

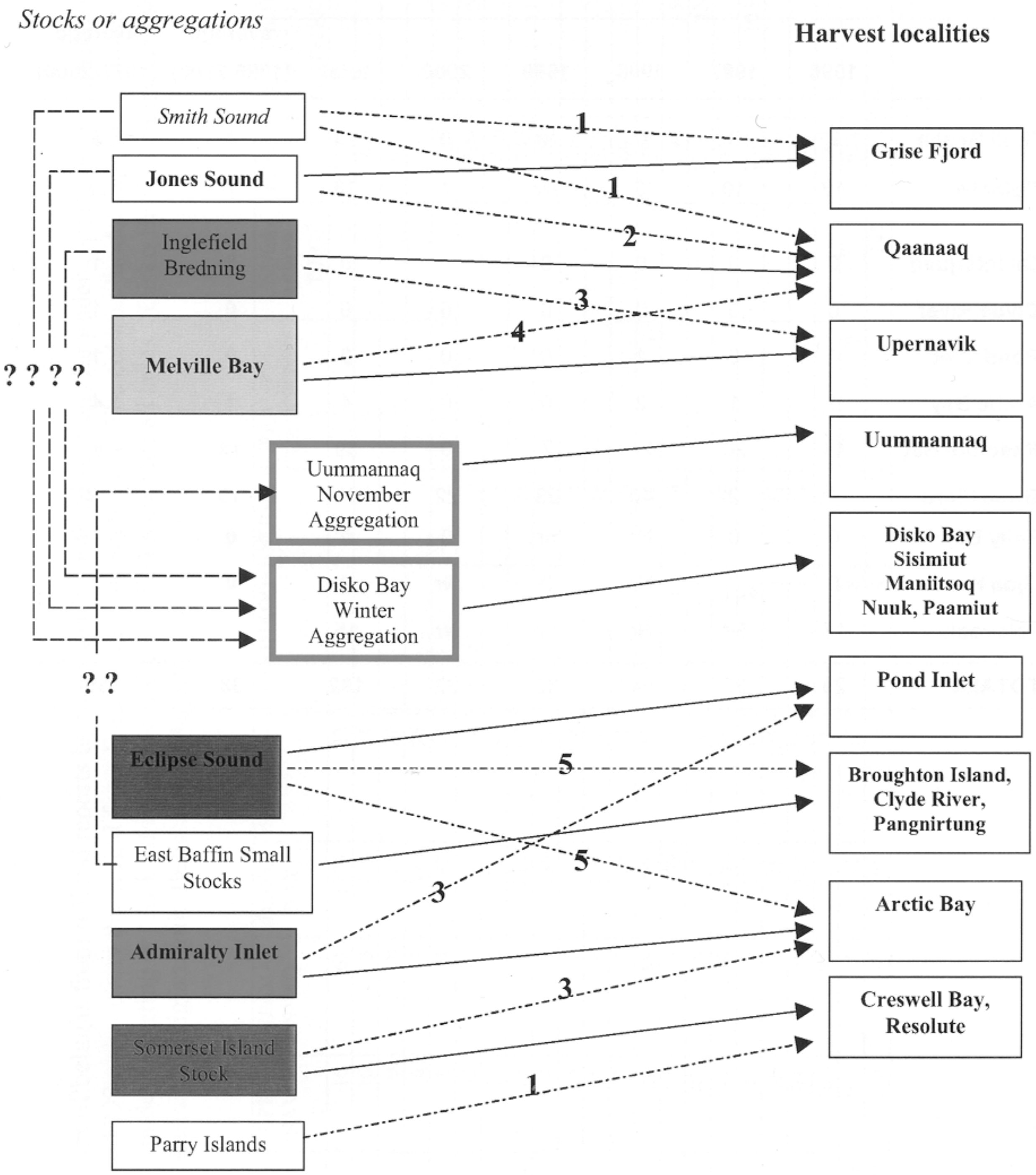

Fig. 3. Conceptual model of the relationships between stocks or aggregations and hunts in different areas for Canadian and West Greenland stocks of narwhals. The dotted darts illustrate unknown levels of contributions to the hunt: 1) indicate probably a very small contribution, 2) indicate a minor contribution during winter months, 3) indicate that hunting may take place along the ice edge in spring, 4) indicate that one settlement, Savissivik, from the municipality of Qaanaaq hunt this stock, and 5) indicate that hunting takes place during autumn migration.

Appendix 1

LIST OF PARTICIPANTS

Carlos Alvarez (NAMMCO),
School of Aquatic and Fishery Sciences
University of Washington
Box 355020, Seattle,
WA 98195, USA
Tel: +1 206 685-4195
Fax: +1 206 685 7471
E-mail: calvarez@uwashington.edu

Dr Brigitte de March (JCBN)
Department of Fisheries and Oceans
Central and Arctic Region
Research Division
501 University Crescent
Winnipeg, Manitoba
R3T 2N6 Canada
Tel: +1 204 983-5103
Fax: +1 204 984-2403
E-mail: DeMarchB@DFO-MPO.gc.ca

Dr Genevieve Desportes (NAMMCO),
Fjord and Belt Centre
Margrethes Plads 1,
DK-5300 Kerteminde,
Denmark
Tel: +45 65 32 57 83
Fax: +45 65 32 42 64
E-mail: genevieve@fjord-baelt.dk

Karen Ditz (JCBN),
Department of Fisheries and Oceans,
Box 358
Iqaluit, NU, Canada
X0A 0H0
Tel: 867-979-8002
Fax: 867-979-8039
E-mail: ditzk@dfo-mpo.gc.ca

Þorvaldur Gunnlaugsson (NAMMCO),
Marine Research Institute,
PO Box 1390,
IS-121 Reykjavik,
Iceland
Tel: +354 5331363
Fax: +354 5623790
E-mail: thg@hafro.is

Dr Mads Peter Heide-Jørgensen (NAMMCO and JCBN),
Greenland Institute of Natural Resources,
c/o National Marine Mammal Laboratory,
National Marine Fisheries Service,
7600 Sand Point Way NE,
Seattle WA 98155
USA
Tel: +1 206 526 6680
Fax: +1 206 526 6615
E-mail: mads peter.heide-joergensen@noaa.gov

Dr Rod Hobbs (NAMMCO),
National Marine Mammal Laboratory,
National Marine Fisheries Service,
7600 Sand Point Way NE,
Seattle WA 98155
USA
Tel: +1 206 526-6278
Fax: +1 206 526-6615
E-mail: Rod.Hobbs@noaa.gov

Kristin Laidre (NAMMCO),
National Marine Mammal Laboratory,
National Marine Fisheries Service,
7600 Sand Point Way NE,
Seattle WA 98155, USA
Tel: +1 206 526-6266
Fax: +1 206 526-6615
E-mail: Kristin.Laidre@noaa.gov

Daniel Pike (NAMMCO),
Scientific Secretary,
North Atlantic Marine Mammal Commission,
Polar Environmental Centre,
N-9296 Tromsø, Norway
Tel: +47 77 75 01 80
Fax: +47 77 75 01 81
E-mail: daniel.pike@nammco.no

Dr Jake Rice (JCBN),
Department of Fisheries and Oceans,
Stock Assessment Secretariat
200 Kent Street, 12 Floor
Ottawa, Ontario
Canada K1A 0E6
Tel: +1 613-990-0288
Fax: +1 613-954-0807
E-mail: RiceJ@dfo-mpo.gc.ca

Pierre Richard (JCBN),
Department of Fisheries and Oceans
Central and Arctic Region
Research Division
501 University Crescent
Winnipeg, Manitoba R3T 2N6
Canada
Phone: +1 204 983-5130
Fax: +1 204 984-2403
E-mail: Richardp@dfo-mpo.gc.ca

Patrice Simon (JCBN),
Department of Fisheries and Oceans,
Fisheries Research Branch
Ottawa, Ontario
Canada K1A 0E6
Tel: +1 613-990-0298
Fax: +1 613-954-0807
E-mail: simonP@dfo-mpo.gc.ca

Dr Rob Stewart (JCBN),
Department of Fisheries and Oceans
Central and Arctic Region
Research Division
501 University Crescent
Winnipeg, Manitoba R3T 2N6
Canada
Phone: +1 204 983-5023
Fax: +1 204 984-2403
E-mail: Stewartre@dfo-mpo.gc.ca

Dr Michelle Wheatley (JCBN),
Director of Wildlife Management,
Nunavut Wildlife Management Board,
P.O. Box 1379
Iqaluit, NU,
X0A 0H0 Canada
Tel: +1 867-979-6962
Fax: +1 867-979-7785
E-mail: Mwheatley@nwmb.com

Dr Øystein Wiig (NAMMCO),
Zoological Museum,
N-0562 Oslo,
Norway.
Tel: +47 22 85 16 88
Fax +47 22 85 18 37
E-mail: oystein.wiig@nhm.uio.no

Dr Lars Witting (NAMMCO and JCBN),
Greenland Nature Research Inst.,
P.O. Box 570,
DK-3900 Nuuk, Greenland.
Tel. +299 32 10 95
Fax +299 32 59 57
Email larsw@natur.gl

List of Hunters that participated to the Biologist – Resource Users meeting:

- Panigpak Daorana, Department of Industry, Huntingdivision, Nuuk, Greenland
- Nuka Møller, Interpreter, Greenland
- Jens Danjelsen, Qaanaaq, Greenland
- Ole Petersen, Upernavik, Greenland
- Ole Møller, Uummannaq, Greenland
- Jeremias Jensen, Ilulissat, Greenland
- Svend Hellmann, Maniitsoq, Greenland
- Kale Mølgaard, Qeqertarsuaq, Greenland
- Isak Reiner, Ilulissat, Greenland
- Peter Ilsur, Ilulissat, Greenland
- Larry Audlaluk, Grise Fiord, Nunavut
- Jooeelee Papatsie, Pangnirtung, Nunavut

Appendix 2

AGENDA

1. Opening remarks

2. Adoption of joint agenda

3. Appointment of Rapporteurs

4. Review of available documents

5. Beluga
    - 5.1 Stock structure
    - 5.2 Age estimation
    - 5.3 Catches
        - 5.3.1 Segregation of sexes and age groups in catches
        - 5.3.2 Stuck and loss study in Nunavut
    - 5.4 Abundance
        - 5.4.1 Re-examination of past aerial surveys
    - 5.5 Ice entrapment events
        - 5.5.1 Relationship to sea surface temperature
        - 5.5.2 Ice entrapment mortality and its significance for population assessment
    - 5.6 Update of assessment
        - 5.6.1 Sustainable harvest levels
        - 5.6.2 Review of research requirements

6. Narwhals
    - 6.1 Stock structure
    - 6.2 Age estimation and life history parameters
    - 6.3 Catches
    - 6.4 Struck and loss Study in Canada
    - 6.5 Abundance
        - 6.5.1 Review of survey plans
    - 6.6 Assessment
        - 6.6.1 Review of research requirements
        - 6.6.2 Sustainable harvest levels
        - 6.4.2 Schedule for assessment

7. Other sources of information
    - 7.1 Local knowledge
    - 7.2 Incidental sightings from other sources

8. Other business

9. Adoption of report

Appendix 3

LIST OF DOCUMENTS

Document No.

SC/9/BN/1 SWG-2001-1	List of participants.
SC/9/BN/2 SWG-2001-2	Agenda.
SC/9/BN/3 SWG-2001-3	Draft list of documents.
SWG-2001-4	de March, B.G.E., Maiers, L.D and Friesen, M.K. An overview of genetic relationships of Canadian and adjacent populations of belugas *(Delphinapterus leucas)* with emphasis on Baffin Bay and Canadian eastern Arctic populations.
SWG-2001-5	Innes, S., Muir, D.C.G., Stewart, R.E.A., Heide-Jørgensen, M.P. and Dietz, R. Stock identity of beluga (*Delphinapterus Leucas*) in Eastern Canada and West Greenland based on organochlorine contaminants in their blubber. [Presented by R. Stewart]
SWG-2001-6	de March, B.G.E., S. Innes and G. Stern**.** The use of organochlorine contaminant profiles for stock discrimination – weaknesses and strengths of multivariate methods. A case study with beluga (*Delphinapterus leucas*) hunted in three communities on Southeast Baffin Island.
SC/9/BN/4	Report of the Workshop to Determine Deposition Rates of Growth Layers in Teeth of White Whales, *Delphinapterus leucas.*
SWG-2001-7	Richard, P. Population dynamics consequence of single growth layer group per year in belugas.
SC/9/BN/5	Heide-Jørgensen, M.P. A proposal for a renewed effort to determine the stock identity of belugas summering in the Canadian high Arctic.
SWG-2001-8	Ditz, K. Catch Statistics for Narwhal and Beluga in selected communities in the Eastern Canadian Arctic (1996-2000).
SWG-2001-9	Innes, S. Population size and yield of Baffin Bay white whale stocks (*Delphinapterus leucas*). [Presented by R. Stewart]
SC/9/BN/6	Laidre, K.L. and M.P. Heide-Jørgensen. Re-examination of the index estimates of beluga abundance off West Greenland 1981 and 1982.
SC/9/BN/7	Alvarez-Flores, C. and Heide-Jørgensen, M.P. Alternative perspectives in the assessment of the beluga hunt in West Greenland.

SC/9/BN/8	Witting, L. Model uncertainty in the assessment of West Greenland Beluga: Inertia versus traditional density regulated dynamics.
SC/9/BN/9	Heide-Jørgensen, M.P., Dietz, R., Laidre, K.L. and Richard, P. Do narwhals from Canada contribute to the harvest in West Greenland?
SWG-2001-10	de March, B.G.E., Maiers, L.D and Tenkula, D. A preliminary analysis of the molecular genetics of narwhal *(Monodon monoceros*) samples collected from Canadian and adjacent waters from 1982-2000.
SC/9/BN/10	Heide-Jørgensen, M.P. Reconstructing catch statistics for narwhals in West Greenland 1862-1999.
SC/9/BN/11	Laidre, K.L., Heide-Jørgensen, M.P. and Dietz, R. Diving behaviour of narwhals *(Monodon monoceros*) in the Canadian Arctic determined by Time Depth Recorders (TDRs).
SWG-2001-11	Richard, P. Proposal for a winter or summer surveys of Baffin Bay narwhals.
SWG-2001-12	Stewart, D.B. Inuit knowledge of beluga and narwhals in the Canadian Eastern Arctic. [presented by K. Ditz]

Annex 3

NAMMCO SCIENTIFIC COMMITTEE WORKING GROUP ON ABUNDANCE ESTIMATES

1. OPENING REMARKS

Chairman Nils Øien welcomed all participants to the meeting (see Appendix 1). He reviewed the terms of reference for the Working Group.

At its 1999 meeting, the NAMMCO Council noted that abundance estimates from NASS-95 have not been completed for some species. The Council therefore recommended that the Scientific Committee complete abundance estimates for all species, as part of its efforts to monitor the abundance of all species in the North Atlantic.

In response, at their meeting in 2000 the Scientific Committee reviewed the present status of analyses and publications from NASS-95, 89 and 87 as well as West Greenlandic aerial surveys. For the most recent survey (NASS-95), only the abundance estimate for minke whales in the Norwegian survey area has been published in the primary scientific literature. Abundance estimates for some other species have been calculated and accepted by the NAMMCO Scientific Committee. For other species, no abundance estimates have been calculated or published. Abundance estimates have been published from the earlier NASS surveys for most species. Only abundance estimates for the target species (minke and fin whales) of the West Greenland aerial surveys have been published.

The Scientific Committee agreed that further analyses of the abundance of non-target species (i.e. all but minke, pilot, fin and sei whales) from the NASS-95 survey should be conducted if they are warranted. However, as the survey was not optimised for these species, it was recognised that the design and conduct of the survey would make this possible to a varying degree, depending on both the species and area in question. The Scientific Committee agreed to reactivate the Working Group on Abundance Estimates to prioritise and carry out further analyses from NASS-95, and this task comprised the first part of the meeting.

At its 1999 meeting, the NAMMCO Council also recommended that the Scientific Committee continue its efforts to co-ordinate future sighting surveys and analyses of the results from such surveys in the North Atlantic. Priority species should be minke whales and fin whales, and the Council recommended that the survey design be optimised for these species. The survey should also be optimised to cover those areas where abundance estimates are most urgently required. In 2000, the Scientific Committee agreed to assign this co-ordinating role to this Working Group, and this task comprised the second part of the meeting.

2. ADOPTION OF AGENDA

The Draft Agenda (Appendix 2) was adopted without changes.

3. APPOINTMENT OF RAPPORTEUR

Daniel Pike, Scientific Secretary of NAMMCO, was appointed as Rapporteur for the meeting.

4. REVIEW OF AVAILABLE DOCUMENTS AND REPORTS

The documents considered by the Working Group are listed in Appendix 3. In addition, working papers from previous meetings of the Working Group, and other published documents, were also available as needed.

5. STATUS OF ANALYSES FROM NASS 95

Working paper SC/9/AE/4 provided a summary of the status of the analyses for each species from NASS-95. The Working Group used this and other information contributed by members to assess the need and potential for further analyses of NASS-95 data.

5.1 Minke whale

Present status of analyses

Norwegian area

An estimate has been accepted by both the NAMMCO and IWC Scientific Committees, and has been published (Schweder *et al.* 1996).

Icelandic aerial survey

Dr David Borchers gave a presentation on the discrepancies between the estimate from the aerial survey done in 1987 from Hiby *et al.* (1989) and that from Borchers *et al.* (MS 1997). The latter estimate was more than double that of Hiby *et al.* (1989). He concluded that the abundance estimate of Borchers *et al.* (MS 1997) was probably positively biased because it neglected errors in measuring angles of declinations. Hiby *et al.* (1989) used duplicate sightings to estimate the magnitude of the measurement errors and had incorporated this into their analysis.

Observer error in distance estimation is a much more severe problem for surveys using cue counting than for those using line transect methods. Borchers presented results of some simple simulations which indicated that positive bias of 100% or more can result if observation error is large. The effect of observation error depends on how wide a shoulder the true detection function has; the narrower the shoulder, the greater the bias for a given level of observation error. This emphasises the need for extreme diligence in obtaining accurate measures of angles of declination in a survey using cue counting.

No duplicate sightings were available from the NASS-95 aerial survey, so bias due to observation error could not be evaluated. Borchers *et al.* (MS 1997) fitted a detection function with a wide shoulder in their analysis, which is less susceptible to bias than a detection function with a narrower shoulder. Nevertheless, the estimate was about 1.8 times that from NASS-87 (Borchers *et al*. 1997) for roughly the same area of coverage. For the reasons given above, the latter estimate might also be positively biased. It was noted that there were problems with the training and performance of the observers during the NASS-95 aerial survey.

In discussing this information the Working Group concluded that the estimate for the NASS-87 Icelandic aerial survey provided in Borchers *et al.* (MS 1997) was very likely positively biased. Although bias in the NASS-95 aerial survey estimate cannot be evaluated with certainty, it too is highly likely to be positively biased.

The Working Group noted that the NAMMCO Scientific Committee had concluded that the NASS-95 aerial survey estimate (Borchers *et al.* MS 1997) was the best available estimate for this area (NAMMCO 1998). Given its discussion above, the Working Group agreed that the NASS-95 aerial survey estimate was problematic and some members believed that it should not be considered as an acceptable estimate for this survey area. Although it had identified some further work to be carried out (see below), it did not believe that this would resolve the problems with the 1995 estimate. The Working Group agreed that it was most profitable to ensure that the planning for the 2001 survey avoided the identified problems such that the resultant estimate is acceptable (see Item 10)

Icelandic and Faroese ship surveys

The estimate of abundance for minke whales from the Icelandic and Faroese components of the NASS-95 survey was developed at the 1997 meeting of this Working Group. Unfortunately there is no documentation of this estimate other than a tabular presentation of the numbers by block in the report of the Working Group (NAMMCO 1998). As this estimate forms part of the estimate for the Central Stock accepted by the NAMMCO Scientific Committee (NAMMCO 1999), the Working Group recommended that a document describing this analysis should be developed and published as a high priority.

A component of the Icelandic shipboard data on minke whale abundance in the CM Small Area northeast of Iceland has been analysed in combination with Norwegian data from the same Small Area in a working paper presented to the IWC Scientific Committee (Borchers *et al.* MS 1998). The IWC Scientific Committee concluded that the estimate would be suitable for use within the Revised Management Procedure (IWC 1999).

Further analyses required

Icelandic aerial survey

The distributions of the declination angles should be investigated to determine if there is evidence of rounding error. A simulation study to determine the sensitivity of the 1995 aerial survey estimate of abundance to various magnitudes of observer error should also be carried out.

Icelandic and Faroese ship survey

The analysis of these data should be documented and published.

5.2 Fin whale

Present status of analyses

Estimates for all areas have been accepted by the NAMMCO Scientific Committee (NAMMCO 1998), but have not been published in a scientific journal. Estimates for species other than minke whales from Norwegian data are presently being re-evaluated, and the intention is to publish results for several species in a single paper. A working paper detailing the Icelandic and Faroese estimates (Borchers and Burt MS 1997) was evaluated by this Working Group in 1997.

Further analyses required

The re-evaluation of the Norwegian analysis should be completed and published. The analyses for the Icelandic and Faroese areas should be published as soon as feasible.

5.3 Sei whale

Present status of analyses

There were too few sightings in the Norwegian and Faroese areas to develop an abundance estimate. A working paper detailing the Icelandic estimate (Borchers and Burt MS 1997) was evaluated by this Working Group in 1997.

Further analyses required

The analysis from the Icelandic area should be published as soon as feasible.

5.4 Pilot whale

Present status of analyses

There were too few sightings of this species to develop an estimate for the Norwegian survey area. An estimate for the Icelandic and Faroese areas has been developed in the form of two working papers (Borchers *et al*. MS 1996, Burt and Borchers MS 1997) and accepted by the NAMMCO Scientific Committee.

Further analyses required
The analyses for the Icelandic and Faroese areas should be published as soon as feasible, including distributional data from the Norwegian survey.

5.5 Humpback whale

Present status of analyses
An abundance estimate for the Norwegian area has been developed but is presently being re-evaluated. There were no observations of humpback whales in the Faroese area.

An abundance estimate for the Icelandic survey area was presented in SC/9/AE/5. A total of 252 sightings of 381 humpback whales were made in the Icelandic survey area. These data were analysed by conventional line transect methodology using the program Distance (Thomas *et al.* 1998). The analysis was stratified by survey block and two Beaufort sea state categories, but estimates of effective strip half-width and mean group size were pooled over these stratification factors. A simple block-stratified analysis was also presented. Both analyses resulted in a point estimate of about 15,000 whales for the survey area, but the precision was much higher for the dual-stratified estimate (95% CI 4,299 - 49,960 for the block-stratified estimate, and 9,675 - 24,093 for the dual-stratified estimate). However, it was noted that the variance in the latter estimate was underestimated to an unknown degree because observations under high and low Beaufort conditions were not independent, and that the estimate of variance will require revision.

In 1995, there were about four times as many sightings, and the resultant point estimate is much higher than that from the NASS-87 (Gunnlaugsson and Sigurjónsson 1990), and also higher than the estimate for the entire North Atlantic from the YoNAH mark-recapture study (Smith *et al*. 1999). A change in the distribution of whales between the 1987 and 1995 surveys was also noted. In 1987, most sightings of humpback whales were made off western Iceland, with a lesser proportion made off eastern and northern Iceland (Sigurjónsson and Gunnlaugsson 1989). In 1995, while sightings were still made off western Iceland, over 50% of the sightings were made in Block 5 off eastern Iceland.

In discussing this estimate, the Working Group noted that the estimate is heavily influenced by the high numbers seen on 1 transect in block 5 off eastern Iceland. While this is an unavoidable consequence of the clumped distribution of humpback whales in this area, it will result in a very high variance for the abundance estimate. As humpback whales are not a priority for the NASS surveys, it is unlikely that a more appropriate survey design for this species will be adopted.

Further analyses required
Norwegian area
The re-evaluation of the estimate for the Norwegian area should be completed and submitted for publication as soon as feasible.

Icelandic area
A further illustration of the sightings and effort by Beaufort sea state category is required, and could probably best be presented as a coded map. The estimate of variance for the dual-stratified estimate should be re-calculated to account for the non-independence of observations across Beaufort categories. Alternatively, this could be done by treating Beaufort sea state as a covariate in the analysis.

5.6 Blue whale

Present status of analyses
There were too few sightings in the Norwegian and Faroese areas to warrant analysis. There were 44 sightings of 65 blue whales in the Icelandic survey area (Sigurjónsson *et al.* MS 1996). However it was noted that not all of these were confirmed sightings of blue whales, but that some were recorded as “like blue” whales. Similarly, an unknown proportion of the many whales recorded as “like fin”

whales may have been blue whales. Even if a small proportion of these were blue whales, this would have a major effect on the accuracy of the analysis. These data have not been analysed.

Further analyses required
The proportion of confirmed vs. "like" blue whales in the Icelandic data should be determined. It can then be decided if further analyses are warranted.

5.7 Sperm whale
Present status of analyses
There were 53 primary sightings of sperm whales in the Norwegian survey area. These data have been analysed but the analysis is being re-evaluated.

There were 76 sightings of 95 animals in the Icelandic area (Sigurjónsson *et al.* MS 1996), and 3 sightings of 3 animals in the Faroese area (Desportes *et al* MS 1996). These data have not been analysed. The Working Group noted that the assumption that all animals are seen on the trackline is certainly false for this deep-diving species, and that correcting for this is problematic. Any estimates produced from conventional line transect methods will therefore be negatively biased. Nevertheless such estimates may be useful as illustrations of the distribution and relative abundance of this species.

Further analyses required
The Working Group recommended that standard line transect analyses should be completed for this species in the Norwegian and Icelandic areas.

5.8 Killer whale
Present status of analyses
There were 38 sightings of this species in the Norwegian survey area, primarily in the Norwegian sea. An abundance estimate has been developed but is presently being re-evaluated. There were 8 sightings of 53 animals in the Icelandic area, and no sightings in the Faroese area. These data have not been analysed.

Further analyses required
The Working Group noted that the sample size was rather low and that there may be problems with group size estimation that will preclude development of a reliable abundance estimate. Nevertheless it would be potentially valuable to analyse all areas simultaneously and perhaps to combine all the NASS surveys to get a synoptic view of distribution and relative abundance over the entire survey area.

5.9 Northern bottlenose whale
Present status of analyses
There were 3 sightings in the Norwegian area, 26 sightings of 95 animals in the Icelandic area and 17 sightings of 68 animals in the Faroese area. These data have not been analysed. The Working Group noted that abundance estimation for this deep-diving species would suffer from the same problems noted for sperm whales above. It was also noted that the distribution of this species was extremely clumped in the Faroese area.

Further analyses required
The Working Group recommended that a standard line transect analysis in the Faroese and Icelandic areas should be conducted as an illustration of the distribution and relative abundance of this species.

5.10 Harbour porpoise
Present status of analyses

There were more than 100 sightings of this species in the Norwegian area, primarily in the North Sea. An analysis of these data will be completed in the near future.

There were 5 sightings of 6 animals in the Faroese area, and 9 sightings from the Icelandic shipboard survey. There were many more sightings from the Icelandic aerial survey. These data have not been analysed. The Working Group considered that it might be valuable to conduct further analyses on the Icelandic aerial survey data, with a view to approximating the distribution and abundance of this species in the area. Other surveys have shown that aerial surveys are only reliable in Beaufort sea conditions of 2 or less for this species, so the data would have to be restricted. Estimates of the proportion of animals seen on the trackline are available from other surveys and could potentially be applied to the Icelandic data.

Further analyses required

The Working Group recommended that the data from the Icelandic aerial survey should be reviewed to determine if there are sufficient observations under Beaufort conditions of 2 or less to warrant analysis.

5.11 Small Delphinidae

Present status of analyses

The Norwegian components of the NASS-95 survey were conducted in passing mode and it was not possible to identify dolphins to species in most cases. There were 180 sightings of dolphin groups. These data have been analysed and presented to the IWC Scientific Committee in a working paper (Øien MS 1996), but have not been published.

The Faroese and Icelandic components of the NASS-95 survey were conducted in delayed closure mode and more effort was made to identify dolphins to species. Sigurjónsson *et al*. (MS 1996) reported 39 sightings of 486 white-sided dolphins, 106 sightings of 1054 white-beaked dolphins and 174 sightings of 1020 unidentified dolphins in the Icelandic area. There were 27 sightings of 341 white beaked dolphins, 106 sightings of 817 common dolphins, 7 sightings of 142 bottlenose dolphins and 60 sightings of 290 unidentified dolphins in the Faroese area (Desportes *et al.* MS 1996).

In 2000 the Scientific Committee noted that previous NASS surveys in the Faroes and Icelandic areas offered the best available opportunities to develop information on the distribution and at least relative abundance of these species. The Working Group considered that the problems of uncertain species identification, uncertain group size estimation, and possible responsive movement of these species would present significant problems for abundance estimation. Nevertheless it was considered that such an analysis would be worthwhile because it would provide a first approximation of the distribution and abundance of this species.

Further analyses required

The Faroese component of the survey was conducted in double-platform mode, and therefore offers some opportunity to deal with the problems of responsive movements and animals missed by the observers. The Icelandic component was conducted in single platform mode and therefore these problems cannot be addressed. There were many unidentified sightings in both areas, but it is possible that some of these sightings might be dropped if they are far from the trackline, and that a method of allocating to species according to the prevalence of known-species animals by area might be developed. The analysis will in any case be "non-standard" and will therefore require more time than usual. It was estimated that the analysis would require up to 3 months of consultant time, at a total cost of approximately NOK 150 K. A more standard or partial analysis could be done for less. As a first step, the Icelandic members agreed to inspect the data for these species to determine if further analyses are feasible.

An analysis of the common dolphin data from the Faroese survey will be conducted in the near future.

6. PLAN FOR CARRYING OUT REQUIRED ANALYSES: WHO WILL DO WHAT, WHEN?

The Working Group developed a prioritised workplan for carrying out further required analyses, and for developing and submitting papers detailing the results of the survey (Table 1). The re-analysis of the Icelandic aerial survey minke whale data, and the documentation of the Icelandic and Faroese shipboard survey for minke whales, were accepted as the highest priority by the Working Group. Abundance estimates from previous analyses of these data have already been accepted by the NAMMCO Scientific Committee and used in the assessment of the Central Stock of minke whales, so the revision of these data might have management implications. The analysis of the Icelandic and Faroese data on *Lagenorhynchus* dolphins was also given high priority because of the importance assigned these species by NAMMCO Council. Other species and areas were considered of somewhat lesser priority.

July 1 2001 was accepted as a target date for submission of papers for publication. However it was recognised that this will depend on the availability of funding and manpower to carry out required analyses and for writing the papers. It was considered preferable to combine the publications in one volume if possible. Donovan indicated that the subject matter was appropriate for the *Journal of Cetacean Research and Management (JCRM)*. He noted that subject to the normal review process and timing considerations, it should be possible to include all NASS-95 papers in the same JCRM issue.

7. IDENTIFICATION OF PRIORITY SPECIES FOR NASS-2001

Minke whales will continue to be of highest priority for the Norwegian component of the surveys, while minke whales and fin whales will be of highest priority in the Icelandic, Faroese and Greenlandic areas. Humpback whales were identified as a secondary priority for the Icelandic and Greenlandic surveys.

8. PRESENT SURVEY PLANS OF NATIONAL RESEARCH PROGRAMMES

8.1 Faroes

The survey will be carried out with one vessel with approximately 28 sea days. The main area of interest is the Faroese Exclusive Economic Zone (EEZ), but the survey area will be defined in cooperation with the other partners. As in previous surveys, a double-platform tracker configuration and delayed closure mode will be used. A crew of 10 observers will be required for the survey. Other activities such as biopsy and bird surveys will be considered but only insofar as they can be done without detraction from the cetacean survey.

8.2 Greenland

Survey plans for large cetaceans in Greenland are coupled to the development of a long-term monitoring program aimed at providing data for the Aboriginal Whaling Management Procedure being developed by the IWC. The present plan for 2001 is for a vessel survey with about 3 weeks of ship time. The area of interest will be the inshore waters of Western Greenland from Kap Farvel north to approximately Sisimiut. The preferred time will be August to September, as this is considered to be the time of greatest minke whale abundance and most stable weather in western Greenland. Plans for the survey will be finalised at a workshop to be held in Seattle in December 2000.

The Working Group noted that the objectives of the Greenlandic survey will be somewhat different from those of the other jurisdictions, which might limit the potential for co-ordination. However, given the potential benefits of such co-ordination, which had not been achieved in previous NASS surveys, the Working Group recommended that the Greenlandic authorities take all possible measures to co-ordinate the timing, area and methodology of the Greenlandic survey with NASS-2001.

8.3 Iceland

Icelandic survey plans are similar to those for 1995 and 1987. Two vessels will be used with approximately 72 days of time. Inshore waters will be surveyed by plane, with about 100 hours dedicated to the survey. The survey area will be defined in concert with the other partners. There is a desire to increase the effectiveness of the survey for small cetaceans insofar as this does not detract from its effectiveness for the target species.

8.4 Norway

Norway has a six-year rotational monitoring program designed to produce abundance estimates for the small areas EB, EC, ES, EN and CM to be used in calculating catch limits by the Revised Management Procedure. The year 2001 is set aside for supplementary coverage of areas which have received less coverage than originally planned. Two blocks in the southeastern Barents Sea (GA and KO) were missed in 2000 and must be covered this year. This will leave approximately six vessel weeks for survey in other areas, with the priority being those blocks that have received less coverage than originally planned. As some of these blocks are adjacent to Faroese and Icelandic areas of interest, this should contribute to an extension of the total survey area. The Norwegian survey will be conducted in passing mode in a double platform configuration.

8.5 Others

Members of the working group will contact officials in the USA and Canada to determine if there are any plans for cetacean surveys in 2001 that might be coordinated with NASS-2001. It was also noted that there are tentative plans for another SCANS survey no earlier than 2002, which should cover portions of the North Sea and waters west of the British Isles.

9. CO-ORDINATION OF SURVEY EFFORT

9.1 Timing

The Working Group agreed that consistent timing was important to the success of the survey. Since 3 jurisdictions (Iceland, Faroes, Norway) agreed that July was the most appropriate month for the survey, it was agreed to centre the survey around mid-July. Greenland will re-consider its plan to survey in August or September in order to co-ordinate more closely with NASS-2001.

9.2 Coverage

To determine the appropriate survey area, the Working Group examined the locations of the sightings of minke and fin whales from NASS-95 and NASS-87. It was considered desirable to cover the coastal waters around Cape Farewell in southern Greenland, as this area is a border between two putative stock areas. It was agreed that Norwegian coverage should be concentrated on the North Sea, while the Icelandic area will include the Jan Mayen (JMC) area. The Faroese portion of the survey will include the Faroese EEZ and adjacent areas. The survey area for NASS-2001 is shown in Fig. 1.

9.3 Potential for increasing survey coverage

See 8.5.

9.4 Funding issues

It was considered unlikely that additional funding for the survey could be found in the limited time available.

10. METHODOLOGY

10.1 Platforms
The survey area will be covered by ship, except for the inshore Iceland area, which will be covered by plane as in previous NASS surveys. It is presently intended that the Greenlandic area will be covered by ship. The Working Group recommended that the Greenlandic survey planning group should give careful consideration to the most appropriate survey platform for this area.

10.2 Survey modes
For both the aerial and ship surveys, it was considered essential that a detailed written protocol be developed. This could be easily adapted from available protocols for other surveys. The protocols for NASS-2001 will be developed by an intersessional subcommittee of the Working Group.

Ship survey
Norway has used a double-platform configuration in previous NASS surveys and the Faroes did the same in the last survey. The Icelandic surveys have been conducted using a single platform, as the main target has been fin whales and it has been assumed that all animals on the trackline are seen. The Working Group agreed that a two-platform configuration will be used by all vessels in 2001. While this will result in increased cost over a single-platform configuration, it has significant advantages including generating data to estimate *g(0)* for both target and non-target species, and to account for responsive movements. It will also assist in species identification and group size estimation.

The Norwegian component of the survey will be conducted in passing mode to maintain consistency with their monitoring program. A delayed closure mode will be used in the Faroese and Icelandic components, with pre-defined rules for closure. In general, the procedure will be to close on all large whales of uncertain identity within 2.5 nm of the trackline in low density areas. In high density areas, a certain proportion of survey time will be allocated to closures, and closures will be conducted on a systematic basis (e.g. every fifth sighting) on large whales within 2.5 nm of the trackline. The frequency of closures will be varied in response to animal density and available survey time, and this will be left to the discretion of the cruise leader.

Aerial survey
The aerial survey will use the cue-counting approach (Hiby and Hammond 1989) for minke and fin whales. An independent observer mode will be used throughout. A detailed survey protocol will be developed intersessionally.

10.3 Stratification and coverage
Figure 1 shows the block structure agreed upon by the Working Group. The Icelandic area was divided into high and low effort blocks according to the expected densities of minke and fin whales based on previous surveys. Table 2 shows the effort allocation to each block. Tracklines will be established at a later date. Factors to be taken into account include the expected movement of some species from south to north and the co-ordination of survey effort on either side of block boundaries.

The outer part of the aerial survey area around Iceland is difficult to survey by plane because of frequent unacceptable weather. It was therefore considered advisable for the vessel survey in the Icelandic area to overlap with the outer part of the aerial survey area. This will allow the estimation whale numbers in this area if portions are missed by the aerial survey, at the expense of a small amount of extra effort in the ship survey.

10.4 Training of observers
The great importance of thorough training of cruise leaders and observers was emphasised by the Working Group. The availability of written survey protocols for both the ship and aerial surveys will

be essential in this regard. For the ship surveys, it was considered desirable to have a joint training meeting with all cruise leaders. The cruise leaders in turn would be responsible for training the observers. For the aerial survey, it will be necessary to dedicate some flying time to training flights. In addition, computer simulation software is available for training of observers, and this will be utilised.

10.5 Distance and angle estimation experiments

In recent surveys several methods have been used to look at bias in angle and distance estimation during shipboard surveys. During SCANS (Hammond *et al*. MS 1995) distance estimation by naked eye and binoculars were tested by a stationary vessel with a dinghy target. Bias was found in both cases and estimated distances during the survey were bias corrected accordingly before use in the analyses. During the NILS survey, angle estimation from angle boards as well as distance estimation by naked eye were tested with a vessel moving in changing tracks towards two stationary buoys. Angle measurements were found to be unbiased but distance estimates were biased. Bias and error in angle and distance estimation was incorporated in the analysis process. During the IWC SOWER Circumpolar cruises, angle and distance estimation are tested by a vessel moving towards two targets.

Training should be carried out throughout the survey. Angle and distance experiments should be conducted at the beginning, midway and at the end of the cruise. There will typically be no bias in angle measurement when angle boards are used correctly. Ideally the experiments should take place under the same conditions as the survey conditions.

In aerial surveys, training is really the only option to ensure accuracy and precision in angle measurement.

10.6 Data collection procedures

Ship survey

The priority for data collection will be the identified target species (see 7.), however data will be collected for all species encountered insofar as this does not compromise data collection for the target species.

On the Norwegian part of the survey, methodology and data collection procedures will be similar to the previous surveys.

On the Faroese and Icelandic parts of the survey, a double-platform configuration will be used. Observers on the tracking platform (TP) will search ahead of the primary platform (PP) and track sightings of target species (minke, bottlenose whale and dolphin groups), until they have been seen by the primary platform or have passed abeam. For other species the tracker platform will act as a primary platform. This methodology follows the one established for the SCANS survey (Hammond *et al*. 1995) and followed by the Faroese vessel during the NASS 95 survey (Desportes *et al*. MS 1996).

The primary platform will have two observers searching with naked eyes in a standard way for line transect surveys and concentrating their searching effort within 1000 m of the vessel. They will be allowed to use binoculars for species identification. Their data will be used to estimate sighting rate and effective strip width. Distances to sightings will be estimated and angles from the trackline to the cues will be read from mounted angle boards. The PP will be audibly and visually isolated from TP, but will be linked to the TP by telephone. Bridge, crew, and other observers will be instructed not to indicate any sightings to the PP.

The TP will have two observers (trackers) searching with mounted binoculars and one other observer, the duplicate identifier (DI). Trackers will search with binoculars, further ahead of the ship than the observers on the PP (i.e. beyond 1000m), within a field of 60° to -10° on each side of the trackline (i.e. 20° overlap between trackers). They should detect animals sufficiently far ahead of the vessel so that they would not yet have reacted to the vessel's presence. Such responsive movement by minke whales may begin 300 to 1,100 metres from the vessel (Palka and Hammond forthcoming). Trackers will attempt to track whales via multiple sightings as they are approached by the vessel, until the animals have either passed abeam or have been detected by the primary platform. The trackers will record their observations on a tape recorder.

Trackers will estimate distances using binocular reticules. The binoculars will be mounted on rotating monopods with a pointer aligned with the binoculars and passing through an angle board to measure angle from the trackline.

The DI will act as a raporteur/co-ordinator. The DI will maintain contact with the PP, assign sighting numbers to all observations and make judgements about duplicate sightings. The DI will also record sighting conditions in real time onto a computer connected to a GPS.

At least 50% of every leg will be covered in a Beaufort sea state not exceeding 4 and with visibility exceeding 1000 m with no rain. Ideally these portions should be equally distributed along the whole leg.

In the Denmark Strait area, legs will be assigned according to the expected position of the ice edge. These legs will be adjusted according to the actual position of the ice edge, with the overall objective of maintaining equal coverage probability. A procedure for adapting the cruise track according to the position of the ice edge will be incorporated into the survey protocol.

Draft protocol and data entry forms will be drafted and circulated to WG members for approval. The same protocol and forms will be used by the Faroese and the Icelandic vessels. In addition a common data entry software will be used.

Aerial survey

The data collection procedures for the aerial survey will be fully explained in the survey protocol (see 10.2).

10.7 Collection of behavioural and ancillary data

Generally, the collection of behavioural data will be of lesser priority than sighting target or non-target species, and will only be carried out insofar as it does not interfere with sightings. Iceland identified a need to collect surfacing data for sperm whales, and this was considered feasible as it will not likely detract from the primary goals of the survey.

The availability of real-time sea surface temperature and other remote sensing information will be investigated by the Secretariat, as this will be useful in interpreting the results of the survey.

10.8 Collection of biopsy samples and tagging

Collection of biopsy samples will be a secondary activity and will be carried out if time and conditions allow at the discretion of the cruise leader. During the Norwegian surveys, biopsy samples are generally collected when conditions will not allow surveying. Priorities for the collection of biopsy samples relate to previously identified stock delineation problems, and will be as follows:

- Minke whales off SE and S Greenland, and in the eastern North Sea;
- Fin whales in the Faroese blocks, off eastern Iceland and in the Jan Mayen area.

It was also noted that minke whale biopsy samples are presently being collected off western Scotland, which will be useful for comparative purposes.

A small number (2-3) of satellite tags will be deployed on fin whales in the Icelandic area.

10.9 Other considerations

The Working Group was informed of the existence of a towed acoustic array for recording vocalisations of small cetaceans. The recorder is designed to be maintenance free once deployed. This was considered to be potentially a valuable addition to the survey, particular to the Norwegian portion in the North Sea. The Working Group agreed to investigate the availability and suitability of this system, and decide on its use at a later date.

11. OTHER ISSUES

Data coding and entry should be carried out during or as soon as possible after the survey. The importance of stringent verification and validation procedures for survey data was emphasised by the Working Group. In this regard Donovan informed the Working Group of the software that is used to validate data from IWC IDCR/SOWER cruises. The data are validated by running a series of programs which check that the value of a variable in a record lies within a certain range, the compatibility of one variable with another variable within the same record, and the consistency between records (eg. calculating speed needed to travel between two points based on their times and positions). Files listing all the errors are produced. Other programs are also available to plot and check positions. The Working Group recommended that similar procedures should be used to validate data produced during the NASS-2001 survey.

The Working Group emphasised that every effort should be made to complete analyses of the abundance of target species as quickly as possible after the completion of the survey. Analyses of the abundance of non-target species are of lesser importance, but should be completed within a reasonable time frame. Analyses of target species abundance should ideally be completed jointly by a standardised methodology.

12. ADOPTION OF REPORT

A draft version of the report was adopted at the meeting, and a complete version was adopted by correspondence on January 17, 2001.

REFERENCES

Borchers, D.L., Burt, M.L. and Desportes, G. (MS) 1996. Preliminary estimates of abundance of long-finned pilot whales (*Globicephala melas*) from the Faroese component of the NASS-95 survey. Working paper WP-9 for the ICES Study Group on Long-Finned Pilot Whales, 22-26 April, 1996.

Borchers, D.L., McCracken, M., Gunnlaugsson, Th., and Burt, M.L. (MS) 1997. Estimates of minke whale abundance from the 1987 and 1995 NASS aerial surveys. Working paper SC/5/AE/2 for the NAMMCO Scientific Committee Working Group on Abundance Estimates.

Borchers, D.L., Øien, N., Gunnlaugsson, Th. and Burt, M.L. (MS) 1998. Minke whale abundance in the NVS stratum of the CM management Area from NASS95. Working Paper SC/50/RMP/10 for the IWC Scientific Committee.

Desportes, G., Bloch, D., Allali, P., Barbraud, C., Egholm, J., Joensen, M., Leroy, B. Mougeot, F., Mouritsen, R. Reinert, A. and Sequiera, M. (MS) 1996. NASS-95, preliminary report of the Faroese cruise. Working Paper SC/4/16 for the 4th Meeting of the NAMMCO Scientific Committee.

Gunnlaugsson, Th. and Sigurjónsson, J. 1990. NASS-87: Estimation of whale abundance based on observations made onboard Icelandic and Faroese survey vessels. *Rep. int. Whal. Commn* 40:571-580.

Hammond, P.S., Benke, H., Berggren, P., Borchers, D.L., Buckland, S.T., Collet, A., Heide-Jorgensen, M.P., Heimlich-Boran, S., Hiby, A.R., Leopold, M.F., And Øien, N. (MS) 1995. Distribution and abundance of the harbour porpoise and other small cetaceans in the North Sea and adjacent waters. SCANS Final Report Life 92-2/UK/027 October 1995.

Hiby, A.R. and Hammond, P.S. 1989. Survey techniques for estimating current abundance and monitoring trends in abundance of cetaceans. *Rep. Int. Whal. Commn* (Special issue 11):47-80.

Hiby, L., Ward, A. and Lovell, P. 1989. Analysis of the North Atlantic Sightings Survey 1987: Aerial survey results. *Rep. int. Whal. Commn* 39:447-455.

[NAMMCO] North Atlantic Marine Mammal Commission. 1998. Report of the fifth meeting of the Scientific Committee. In: NAMMCO Annual Report 1997, NAMMCO, Tromsø, pp. 85-202.

[NAMMCO] North Atlantic Marine Mammal Commission. 1999. Report of the sixth meeting of the Scientific Committee. In: NAMMCO Annual Report 1998, NAMMCO, Tromsø, pp. 89-131.

Øien, N. (MS) 1996. *Lagenorhychus* species in Norwegian waters as revealed from incidental observations and recent sighting surveys. Working Paper SC/48/SM/15 for the IWC Scientific Committee.

Palka, D.L. and Hammond, P.S. 2001 Accounting for responsive movement in line transect estimates of abundance. *Can J. Fish. Aquat. Sci.* Forthcoming.

Schweder, T., Skaug, H.J., Dimakos, X.K., Langaas, M. and Øien, N. 1996. Abundance of northeastern Atlantic minke whales, estimates for 1989 and 1995. *Rep. Int. Whal. Commn* 47:453-484.

Sigurjónsson, J., and Gunnlaugsson, Th. 1989. NASS-87: Shipboard sightings surveys in Icelandic and adjacent waters June-July 1987. *Rep. int. Whal. Commn* 40:571-580.

Sigurjónsson, J., Víkingsson, G., Gunnlaugsson, Th., and Halldórsson, S.D. (MS) 1996. North Atlantic Sightings Surveys 1995 (NASS-95): Shipboard surveys in Icelandic and adjacent waters, June-July 1995, Preliminary cruise report. Working Paper SC/4/18 for the 4th Meeting of the NAMMCO Scientific Committee.

Smith, T.D., Allen, J., Clapham, P.J., Hammond, P.S., Katona, S., Larsen, F., Lien, J., Mattila, D., Palsbøll, P.J., Sigurjónsson, J., Stevick, P.T. and Øien, N. 1999. An ocean-basin-wide mark-recapture study of the North Atlantic humpback whale (Megaptera novaengliae). *Mar. Mam. Sci*. 15:1-32.

Thomas, L., Laake, J.L., Derry, J.F., Buckland, S.T., Borchers, D.L., Anderson, D.R., Burnham, K.P., Strindberg, S., Hedley, S.L., Burt, M.L., Marques, F.F.C., Pollard, J.H. and Fewster, R.M. 1998. Distance 3.5. Research Unit for Wildlife Population Assessment, University of St. Andrews, UK. Available: http://www.ruwpa.st-and.ac.uk/distance/

Table 1. Further analyses to be carried out from NASS-95. Priority- H = High, M = Medium, L = Low, Area- F = Faroes, I = Iceland, N = Norway.

Priority	Species	Area	Task	Who	Target Date
H	minke	I (aerial)	Evaluate the frequency distributions of the radial distance data to determine if there is evidence of rounding error. Carry out a simulation study to determine the sensitivity of the analysis to various degrees of observer error.	Consultant	Jul. 1 2001
H	minke	I,F (ship)	The analysis of these data should be documented and published.	Consultant	Jul. 1 2001
H	Delphinidae	I,N,F	Inspect Icelandic data to determine if the level of analysis that is warranted. Carry out required analyses on the Icelandic and Faroese data. Submit paper for publication.	Consultant	Jul.1 2001
H	fin	N	Complete re-evaluation of abundance estimate.	Øien	Jul. 1 2001
H	humpback	N	Complete re-evaluation of abundance estimate.	Øien	Jul. 1 2001
M	humpback	I	Provide information on sightings and effort by Beaufort sea state category. Revise variance estimate to account for non-independence of observations across Beaufort sea state categories.	Pike, Gunnlaugsson	Apr. 1 2001
M	N. bottlenose	I,F	Complete standard line transect abundance estimates.	Pike, Gunnlaugsson	Jul. 1 2001
M	H. porpoise	N	Complete abundance estimate and submit paper.	Øien	Jul. 1 2001
M	H. porpoise	I	Review Icelandic aerial survey to determine if there are sufficient observations under Beaufort conditions of 2 or less to warrant analysis. If so, proceed with analysis.	Gunnlaugsson, consultant	Jul. 1 2001
M	blue	I	Determine proportion of confirmed vs. “like” blue whale sightings. If it is determined to be sufficient, proceed with standard line transect analysis	Gunnlaugsson, Pike	Jul. 1 2001
L	sperm	N,I	Complete standard line transect abundance estimates.	Øien, Gunnlaugsson, Pike	Jul. 1 2001
L	killer	N,I	Complete standard line transect abundance estimate, perhaps combining data from 2 or all NASS surveys.	Gunnlaugsson,	Jul. 1 2001

Table 2.[1] Estimated effort allocation to survey blocks, NASS-2001.

Area	**Date**	**Ship Days**	**Hrs/ day**	**Realisable Effort (%)**	**Block**	**Area (K nm^2)**	**Effort (nm)**	**Coverage (nm/nm^2)**	**Allocation (%)**
Norway	27.06-7.08	35	18	40	N-1	75	2,500	0.033	23
Faroes	26.06-26.07	28	18	40	F-1	199	2,000	0.010	19
Iceland North	20.06-25-07	33	20	50	I-1	167	2,200	0.013	20
					I-2	74	1,100	0.015	10
Iceland South	19.06-12.07	33	18	50	I-4, I-5	75	2,140	0.027	20
					I-3	116	860	0.009	8
TOTAL		**129**				**703**	**10,800**		

[1]This table was revised after the meeting when errors were found in the original block area estimates.

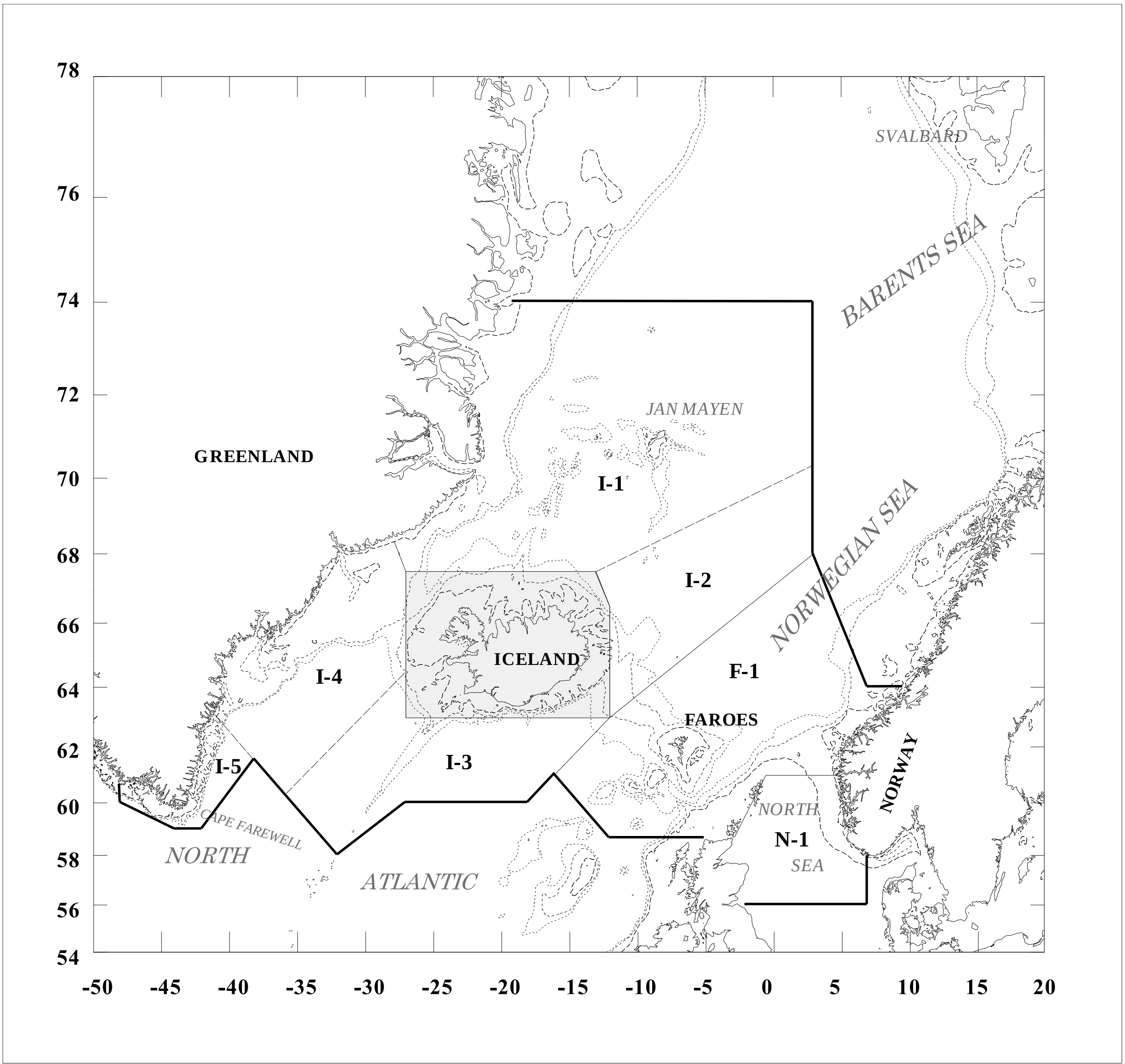

Fig. 2. NASS-2001 survey area, identifying blocks to be covered by Faroese, Icelandic and Norwegian vessels. The shaded area around Iceland will be covered by aerial survey.

Appendix 1

LIST OF PARTICIPANTS

Dr Dorete Bloch
Natural History Museum,
Futalag 40,
FR-100 Tórshavn,
Faroe Islands
Tel: +298 31 85 88
Fax: +298 31 85 89
E-mail: doreteb@ngs.fo

Dr David Borchers
Research Unit for Wildlife Population Assessment,
Maths Institute, North Haugh
University of St Andrews
Fife, KY16 9SS
Scotland
Tel: +44 1334 463806
Fax: +44 1334 463748
E-mail: dlb@st-and.ac.uk

Dr Genevieve Desportes,
Fjord and Belt Centre
Margrethes Plads 1
DL-5300 Kerteminde
Denmark.
Tel: +45 65 32 57 83
Fax: +45 65 32 42 64
E-mail: genevieve@fjord-baelt.dk

Mr Greg Donovan
Scientific Editor
International Whaling Commission
The Red House
135 Station Road
Impington, Cambridge
UK CB4 9N9
Tel: +44 1233 233 971
Fax: +44 1233 232 876
E-mail: gregiwc@compuserve.com

Mr Þorvaldur Gunnlaugsson
Marine Research Institute,
PO Box 1390,
IS-121 Reykjavik,
Iceland
Tel: +354 5331363
Fax: +354 5623790
E-mail: thg@halo.is

Dr Phil Hammond
Sea Mammal Research Unit
University of St Andrews
St Andrews, Fife KY16 8LB
Scotland
Tel: +01 334 462630/463222
Fax: +01 334 462632
E-mail: psh2@st-andrews.ac.uk

Dr Grete Hovelsrud-Broda
General Secretary,
North Atlantic Marine Mammal Commission,
University of Tromsø,
N-9037 Tromsø,
Norway
Tel: +47 77 64 59 04
Fax: +47 77 64 59 05
E-mail: gretehb@nammco.no

Dr Nils Øien (Chairman)
Institute of Marine Research
P.O.Box 1870 Nordnes
N-5024 Bergen
Norway
Tel: +47 55 23 86 11
Fax: +47 55 23 86 17
E-mail: nils@imr.no

Mr Daniel Pike
Scientific Secretary,
North Atlantic Marine Mammal Commission,
Polar Environmental Centre,
N-9296 Tromsø, Norway
Tel: +47 77 75 01 80
Fax: +47 77 75 01 81
E-mail: dan.pike@nammco.no

Dr Hans Skaug
Institute of Marine Research
P.O.Box 1870 Nordnes
N-5024 Bergen
Norway
Tel: +47 55 23 84 25
Fax: +47 55 23 86 87
E-mail: skaug@imr.no

Mr Gisli Vikingsson
Marine Research Institute,
PO Box 1390,
IS-121 Reykjavik,
Iceland
Tel: +354 5520 240
Fax: +354 5623 790
E-mail: gisli@hafro.is

Dr Lars Witting
Greenland Nature Research Institute
P.O.Box 570
DK-3900 Nuuk
Greenland
Tel: +299 32 10 95
Fax: +299 32 59 57
E-mail: larsw@natur.gl

Appendix 2

AGENDA

1. Opening remarks

2. Adoption of Agenda

3. Appointment of Rapporteur

4. Review of available documents and reports

Part 1: Further development of abundance estimates from NASS 95

5. Status of analyses from NASS 95
    - 5.1 Minke whale
        - 5.1.1 Present status of analyses
        - 5.1.2 Further analyses required
    - 5.2 Fin whale
        - 5.2.1 Present status of analyses
        - 5.2.2 Further analyses required
    - 5.3 Sei whale
        - 5.3.1 Present status of analyses
        - 5.3.2 Further analyses required
    - 5.4 Pilot whale
        - 5.4.1 Present status of analyses
        - 5.4.2 Further analyses required
    - 5.5 Humpback whale
        - 5.5.1 Present status of analyses
        - 5.5.2 Further analyses required
    - 5.6 Blue whale
        - 5.6.1 Present status of analyses
        - 5.6.2 Further analyses required
    - 5.7 Sperm whale
        - 5.7.1 Present status of analyses
        - 5.7.2 Further analyses required
    - 5.8 Killer whale
        - 5.8.1 Present status of analyses
        - 5.8.2 Further analyses required
    - 5.9 Northern bottlenose whale
        - 5.9.1 Present status of analyses
        - 5.9.2 Further analyses required
    - 5.10 Harbour porpoise
        - 5.10.1 Present status of analyses
        - 5.10.2 Further analyses required
    - 5.11 Small delphinidae
        - 5.11.1 Present status of analyses
        - 5.11.2 Further analyses required

6. Plan for carrying out required analyses: Who will do what, when?

6.1 Prioritising required analyses
6.2 Workplan
6.3 Plans for publication

Part II: Planning NASS 2001

7. Identification of priority species

8. Present survey plans of national research programmes
   8.1 Faroes
   8.2 Greenland
   8.3 Iceland
   8.4 Norway
   8.5 Others

9. Co-ordination of survey effort
   9.1 Timing
   9.2 Coverage
   9.3 Potential for increasing survey coverage
   9.4 Funding issues

10. Methodology
   10.1 Platforms
   10.2 Survey modes
   10.3 Stratification and coverage
   10.4 Training of observers
   10.5 Distance and angle estimation experiments
   10.6 Data collection procedures
   10.7 Collection of behavioural and ancillary data
   10.8 Collection of biopsy samples and tagging
   10.9 Other considerations

11. Other issues

12. Adoption of report

Appendix 3

LIST OF DOCUMENTS AND ORAL PRESENTATIONS

Document No.	
SC/9/AE/1	List of participants
SC/9/AE/2	Draft agenda
SC/9/AE/3	Draft list of documents
SC/9/AE/4	Pike, D.G. Status of analyses and publications from NASS-95.
Oral pres.	Borchers, D.L. Status of analyses of minke whale abundance in the Icelandic and Faroese survey areas from NASS-95 and earlier surveys.
SC/9/AE/5	Pike, D.G. A preliminary estimate of humpback whale (*Megaptera novaeangliae*) abundance in the North Atlantic, from NASS-95 shipboard survey data.
SC/9/AE/6	Desportes, G. Survey plan, 2001, Faroes
SC/9/AE/7	Witting, L., Heide-Jørgensen, M-P. and Kingsley, M. Survey plans for large cetaceans in Greenland 2000. Includes as a supplement: Witting, L. (MS) 2000. Protocols for the West Greenland inshore sighting survey 2000. Working Paper SC/52/AS/6 for the Scientific Committee of the International Whaling Commission.
SC/9/AE/8	Víkingsson, G.A. and Gunnlaugsson, Th. North Atlantic Sightings Survey 2001 (NASS-2001). Survey plans in Icelandic and adjacent waters.
SC/9/AE/9	Survey plan, 2001, Norway.
Oral pres.	Borchers, D.L. Cue counting, considerations for survey design and data collection.

MEMBERS OF THE NAMMCO SCIENTIFIC COMMITTEE – 2001

Faroe Islands

Dorete Bloch
Museum of Natural History
Fútalág 40, FR-100 Tórshavn, Faroe Islands
Tel.: +298 318 588
Fax: +298 318 589
Email: doreteb@ngs.fo

Geneviève Desportes
Fjord and Belt Centre
Margrethes Plads 1
DK-5300 Kerteminde, Denmark
Tel.: +45 65 32 57 83
Fax: +45 65 32 42 64
Email: genevieve@fjord-baelt.dk

Bjarni Mikkelsen
Museum of Natural History
Fútalág 40, FO-100 Tórshavn, Faroe Islands
Tel.: +298 318 588
Fax: +298 318 589
Email: bjarnim@ngs.fo

Greenland

Mads Peter Heide-Jørgensen
Greenland Institute of Natural Resources,
c/o National Marine Mammal Laboratory,
National Marine Fisheries Service/NOAA,
7600 Sand Point Way NE,
Seattle,
WA 98115 USA
Tel.: +1 206 526 6680
Fax: +1 206 526 6615
Email: mads peter.heide-joergensen@noaa.gov

Aqqalu Rosing-Asvid
Greenland Nature Research Inst.
Dalgas Have 50 B 2. lejl. G
2000 Frederiksberg, Denmark.
Tel.: +45 35 32 12 92
Fax: +45 35 32 21 99
Email: ARosing-Asvid@zi.ku.dk

Lars Witting
Greenland Nature Research Inst.
P.O.Box 570,
DK-3900 Nuuk, Greenland
Tel.: +299 32 10 95
Fax: +299 32 59 57
Email: larsw@natur.gl

Iceland

Þorvaldur Gunnlaugsson
Marine Research Institute,
PO Box 1390,
IS-121 Reykjavik, Iceland
Tel.: +354 5331363
Fax: +354 5623790
Email: thg@halo.is

Droplaug Ólafsdóttir
Marine Research Institute,
PO Box 1390,
IS-121 Reykjavik, Iceland
Tel: +354 5520 240
Fax: +354 5623 790
e-mail: droplaug@hafro.is

Gísli A. Víkingsson (Chairman)
Marine Research Institute
P.O. Box 1390
IS-121 Reykjavik, Iceland
Tel.: +354 55 20240
Fax: +354 5 623790
Email: gisli@hafro.is

Norway

Tore Haug
Norwegian Institute of
Fisheries and Aquaculture
N-9291 Tromsø, Norway
Tel.: +47 77 62 92 20
Fax: +47 77 62 91 00
Email: toreh@fiskforsk.norut.no

Christian Lydersen
Norwegian Polar Institute
Polarmiljøsenteret
N-9296 Tromsø, Norway
Tel: +47 77 75 05 23
Fax: +47 77 75 05 01
Email: christia@npolar.no

Nils Øien (Vice Chairman)
Institute of Marine Research
P.O.Box 1870 Nordnes,
N-5024 Bergen, Norway
Tel.: +47 55 23 86 11
Fax: +47 55 23 86 17
Email: nils@imr.no

Ex-Officio Members

Grete Hovelsrud-Broda,
General Secretary,
North Atlantic Marine Mammal Commission,
Polar Environmental Centre,
N-9296 Tromsø, Norway
Tel: +47 77 75 01 80
Fax: +47 77 75 01 81
E-mail: gretehb@nammco.no

Daniel Pike,
Scientific Secretary,
North Atlantic Marine Mammal Commission,
Polar Environmental Centre,
N-9296 Tromsø, Norway
Tel: +47 77 75 01 80
Fax: +47 77 75 01 81
E-mail: daniel.pike@nammco.no