SCIENTIFIC COMMITTEE

REPORT OF THE TENTH MEETING

Hvalfjörður Whaling Station, 17-19 September, 2002

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EXECUTIVE SUMMARY

The tenth meeting of the NAMMCO Scientific Committee was held 17-19 September at the whaling station at Hvalfjörður, Iceland.

MODELLING MARINE MAMMAL - FISHERIES INTERACTIONS IN THE NORTH ATLANTIC

At its 8th meeting, the NAMMCO Council tasked the Scientific Committee with providing advice on the economic aspects of marine mammal-fisheries interactions. A Working Group on the Economic Aspects of Marine Mammal - Fisheries Interactions met in February 2000 to consider parts 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 a workshop to further investigate the methodological and analytical problems in estimating consumption by marine mammals. This workshop was held in Tromsø in September 2001 and resulted in, among other things, a list of research priorities to refine existing estimates of consumption by North Atlantic marine mammals (NAMMCO 2002).

The Scientific Committee viewed the next logical step in this process to be a review of how presently available ecosystem models can be adapted in order to increase our understanding of and quantifying marine mammal - fisheries interactions. The Workshop was held in Reykjavik in September 2002. It was tasked with choosing a preferred modelling approach for analysing the ecological role of minke whales, harp and hooded seals, and other marine mammal species in the North Atlantic, identifying required input data, and recommending a process for further development. The Working Group was not expected to review results or make quantitative predictions at the meeting, but rather to focus on methodological problems.

Available multi-species models

The Working Group considered descriptions of the range of available multi-species modelling tools. This includes two general classes of models typified by the Minimum Realistic Models (MRM) on the one hand and the ECOSIM/ECOPATH approach on the other. The MRM class includes MULTISPEC, BORMICON/GADGET and Scenario Barents Sea. These models share the characteristics of being system specific, modelling only a small component of the ecosystem for a specific purpose, and treating lower trophic levels and primary production as constant or varying stochastically. In contrast, ECOPATH/ECOSIM is an all-inclusive approach that incorporates lower trophic levels and primary production. Mass balance equations are used, essentially relating production by some species to predation by others under the assumption that the system is in a steady-state. ECOSIM builds upon this approach, but drops the equilibrium assumption so that the system is modelled by a set of coupled differential equations. Potentially ECOSIM, like the MRM class of models, could provide a basis to provide advice on marine mammal-fisheries interactions.

Recommended modelling approach for NAMMCO

Considering the data available or likely to become available in the foreseeable future, the Working Group favoured the approach of using a limited model that encompassed only the major species of interest, as opposed to an all-encompassing model where all or most species are included, as a basis for potential management advice in the short to medium term. This approach can be described as a Minimum Realistic-type model, as exemplified by Scenario Barents Sea, MULTSPEC and BORMICON. Other components of the ecosystem that are not explicitly modelled, such as primary production or zooplankton, could be left as constant, allowed to vary randomly or linked to environmental covariates.

The Working Group considered that the ECOPATH/ECOSIM package, while providing a viable framework for some types multi-species modelling, was not entirely suited to the usage envisioned by NAMMCO. Potential disadvantages discussed included the in-built functional forms for species interactions, and simplified treatment of age-structure, that may not be appropriate for the particular cases to be considered. Another problem is the large number of parameter values that need to be specified; some of these may have an appreciable impact on outputs, and the default suggestions provided by the package may not be the most appropriate in all circumstances.

Some members voiced the concern that the development of ecosystem models without sufficient data in some components would produce results that might be used inappropriately by managers, who might not understand the level of uncertainty in the results even if it is specified. However it was agreed that the two activities should proceed simultaneously: that is, the data gaps identified should be filled by dedicated studies, while modelling can proceed in candidate areas, even with partial data, as long as the uncertainty of the results is emphasised and integrated in the results. In this way, modelling approaches can be refined and the reliability of the results will improve as more data is gathered.

There was agreement that the continued development of the Scenario Barents Sea model should be a priority, with emphasis on incorporating the predation of harp seals in the model. In addition the Working Group recommended the development of a second, more general North Atlantic "template" model based on the GADGET platform. This spatially homogeneous model would include species important in candidate applications to West and East Greenland, Iceland and the Barents and North Seas. However the abundance of these species would be varied between the areas according to available information. In areas where data is lacking, such as West Greenland, the main use of such a model will be to identify the sensitivities to variation in input parameters, and thus to assist in the setting of priorities for research. In Icelandic waters, where better data is available for fish but data on marine mammal diets and prey selection are scarce, such a model will serve the same purpose but also generate preliminary scenario results for management. For the relatively data-rich Barents Sea area, the model will augment the main Scenario Barents Sea modelling effort.

In reviewing the amount of multi-species modelling work and associated applications to management decisions that had been conducted world-wide over the past several years, the Working Group noted a much lower than expected activity in this area. This was considered surprising given the emphasis politicians and management authorities have placed on multi-species (ecosystem) approaches to the management of marine resources. While the principle of multi-species management seems to be widely accepted, the practical aspects of putting it into practice lag far behind the rhetoric. The Working Group emphasised that progress in this area will not be made unless significant additional resources are dedicated to it.

Research needs

The Working Group reiterated the research priorities identified by the NAMMCO Scientific Committee in 2001 (NAMMCO 2002). In particular the Working Group emphasised that additional information on harp seal diet and consumption in the Barents Sea is a priority to further the modelling work. The functional nature of prey selection by marine mammals under varying levels of prey abundance and from mixtures of available prey was also considered a priority for further research. To derive these functions diet data must be collected in conjunction with resource surveys at appropriate temporal and spatial scales. In addition the Working Group identified the following priorities:

Prey selection:

- theoretical and practical work on prey selection models
- development aggregated consumption functions
- migratory and spatial aspects of consumption models

Multi-species modelling:
- Further work on the Scenario Barents Sea model
- Use GADGET as a framework to generate template models for candidate areas in the North Atlantic

It was considered that discussion of the economic aspects of marine mammal-fisheries interactions would be premature until at least one of the two models above has been developed. Once models are available that can predict the variation in target species in response to management measures, linkages to simple economic models that assess the economic consequences of the responses can be made.

Discussion by Scientific Committee
The Scientific Committee supported the conclusion of the Working Group that progress in the development and application of multi-species approaches to the management of marine resources was lagging far behind the stated need of management agencies for such approaches, and again emphasised that progress in this area will not be made unless significant additional resources are dedicated to it.

The Scientific Committee considered that it may have identified a way forward in addressing the requests from the Council, but stressed the importance of completing the necessary modelling work and collection of required input data before further progress on this matter can be made. For the modelling work, further progress cannot be made outside of the Barents Sea candidate area without additional resources, and the modelling effort for the Barents Sea could be enhanced with additional funding and manpower. Priorities for the collection of input data have been identified previously (NAMMCO 2000, 2001) but it cannot be expected that these data gaps can be filled within a short time frame, even if new resources are dedicated to the activity. If new resources are not available, the required input data cannot be collected and it will not be possible to provide the advice to the Council.

Witting, however, pointed out that even if required data should be collected, Minimum Realistic Models might not be able to realistically project the effects of an increased or decreased harvest of marine mammals. He argued that to firmly analyse the ecological effects of changes in the harvest of marine mammals a detailed understanding of the predator prey and competitive interactions of all relevant species is needed including a description of the density and prey dependent changes in the consumption functions of all species. While models that include all these interactions may, in principle, be able to predict the ecological impact of changed harvest levels, they represent unrealistic modelling approaches because it will be essentially impossible to estimate all the parameters. For most cases, he therefore found that it is unwise to base management on the predictions of multi species models, although he agreed that these models are needed for a more basic scientific level in order to obtain a better understanding of various ecosystems.

While there was some disagreement as to the suitability of minimum realistic models in general for providing management advice, it was agreed that this type of model was superior to the available alternatives. The Scientific Committee will assess any future modelling efforts critically with regard to the quality of input data, modelling assumptions and realism before deciding if any advice can be given.

The Scientific Committee agreed that the next meeting of the Working Group should focus on assessing modelling results from the Scenario Barents Sea model and possibly the GADGET-based template models for other areas, if they are developed. The Working Group should also consider the feasibility of connecting the multi-species models with simple economic models at that time. Walløe agreed to provide the Scientific Committee with a report on progress in the modelling efforts identified by the Working Group at next year's meeting. The Scientific Committee will assess progress made in modelling and in the collection of input data and decide at that time whether enough progress has been made to warrant another meeting of the Working Group.

HARP AND HOODED SEALS

An aerial survey for harp seals in the Greenland Sea was carried out during the period 14 March to 6 April 2002. The last survey was carried out in 1991. The results from the aerial surveys will be used to estimate the total 2002 harp seal pup production. Subsequently, the status of the stock will be assessed by fitting population models to the pup production estimate. The ICES Working Group on Harp and Hooded Seals will meet in September 2003 to review these results and provide advice on stock management.

NARWHAL

The Council has recommended that the Scientific Committee should concentrate its assessment efforts on the West Greenland narwhal in the near term, and that this assessment should be done jointly with the JCNB if possible. The Scientific Committee was informed about recent progress in satellite tagging and abundance surveys of narwhal in Greenland and Arctic Canada. A future assessment of narwhals in West Greenland may require two consecutive meetings to answer specific questions and to set scenarios for runs of population models. The Scientific Committee considered it advisable to hold the first assessment meeting in 2004, when surveys from several areas will have been completed and analysed. A subsequent meeting, probably in 2005, could deal with both narwhal and the new survey data for beluga which should be available at that time. Planning for future assessments will have to be done in conjunction with the Scientific Working Group of the JCNB, of which Witting is Chairman. He agreed to liaise between the two groups to find the best way to carry the assessment forward.

BELUGA

Some new results from satellite tracking of belugas have become available since the Scientific Committee last performed an assessment in 2001, but the information does not provide a basis for altering the present advice. The next survey of belugas on the wintering ground in West Greenland is planned to be conducted in March 2004. Results from this survey will – assuming successful completion – be available for revising the present advice in the autumn of 2004 or in 2005.

The Scientific Committee noted with satisfaction the progress in implementing a quota system for beluga and narwhal in Greenland, but further noted that recent harvest figures for Greenland indicate that little or no reduction in catch has taken place. The Committee has advised on 2 occasions (2000 and 2001) that the stock is substantially depleted and that present harvests are several times the sustainable yield, and that harvests must be substantially reduced if the stock is to recover. The Committee stressed that the apparent delay in reducing the catch to about 100 animals per year will result in further population decline and will further delay the recovery of this stock.

FIN WHALES

In 2002 the Council clarified its previous request for advice on fin whales, asking that the Scientific Committee continue with its assessments of fin whale stocks in the areas of interest to NAMMCO countries with existing and new information on abundance and stock delineation as it becomes available.

An estimate of the abundance of fin whales from the NASS-2001 survey has been completed. The Committee noted that abundance estimates from the Norwegian survey area of the NASS-1995 survey have not been published, and estimates from subsequent surveys in the Norwegian area have not yet been produced. The Committee recommended that these estimates be completed on a timely basis.

Efforts to tag fin whales with satellite-linked tags have continued in the Faroes, Greenland and Iceland. In the Faroes, 12 tag deployments have been made in the past 2 years, of which 2 have transmitted data. One of

these animals moved into the waters west of Bay of Biscay. Collection of tissue samples for genetic analysis has continued in the Faroes, Greenland, and Norway. In the Faroes and Norway, samples are collected through a biopsy program, while in Greenland samples are taken from the annual catch. Iceland has a large collection of tissue samples from historical catches, however virtually all of these are from western Iceland. The Committee noted that satellite tagging had indicated an apparent connection between fin whales in Faroes and in the waters near Spain and urged the addition of tissue samples from fin whales in these waters to ongoing studies on stock structure of North Atlantic fin whales.

The Scientific Committee noted that the success rate of deploying satellite tags on fin whales and other large whales was low and variable between research teams. There are several research groups working on large whale tagging in NAMMCO member countries, the USA, Japan and other countries, and the field is quite competitive. The Committee decided to establish an intersessional correspondence group to:

- identify progress in satellite tagging made in NAMMCO member countries and elsewhere;
- explore the technical aspects of satellite tagging, including deployment systems;
- briefly consider what tagging experiments have been done and the rates of success;
- recommend ways to further the development and success of this technique in NAMMCO member countries.

The Committee will report their findings at next years meeting of the Scientific Committee.

The Scientific Committee considered that the new abundance data for the Faroese and Icelandic areas could allow the assessments for these areas to be updated in the coming year. An assessment of fin whales in the Norwegian area could be attempted if abundance estimates for the area are completed. Consideration should be given to contracting an update of the genetic analysis including new samples from the Faroes.

MINKE WHALES

In 2002 the Council recommended that the Scientific Committee should complete an assessment of Central Atlantic minke whales once new abundance estimates from NASS-2001 become available.

Estimation of abundance from the 2001 aerial survey and a reanalysis of the 1987 aerial survey data are presently being conducted under contract. Analysis of the ship survey data from 2001 is in progress. Analysis of the 1996-2001 series of Norwegian sightings surveys, which includes part of the Central Atlantic stock, has been completed and reported to the IWC. An aerial digital photographic survey of minke whales and other species is being conducted in 2002 in West Greenlandic waters, and will be repeated in 2003. Satellite tags have been deployed on 2 minke whales this year in Icelandic waters. Genetic analyses of the large number of samples from the Norwegian catch are ongoing. However more samples from surrounding areas, including the Faroes and Iceland, are required to refine the analysis. The Scientific Committee recommended that tissue samples be collected from these areas by biopsy or other means.

The Scientific Committee considered that a new assessment of the Central Atlantic stock could be conducted after the Working Group on Abundance Estimates has considered the new estimates from the Icelandic aerial survey and the Icelandic and Faroese ship surveys from NASS-2001.

WHITE-BEAKED, WHITE-SIDED DOLPHINS AND BOTTLENOSE DOLPHINS

An abundance estimate for primarily white-beaked dolphins from the NASS-2001 Icelandic aerial survey has been produced, and estimates from previous aerial surveys are in progress. Estimates from the ship surveys have not been developed. Sampling programs from Icelandic bycatch of whitebeaked and the Faroese drive hunt whitesided and bottlenose dolphins have been conducted, and reports on life history and general ecology should be produced in the coming year. Norway will be initiating a sampling program

involving the collection of approximately 60 whitebeaked dolphins for life history, genetic and feeding analyses. In addition biopsy samples are collected during sightings surveys.

At this point the Scientific Committee considered that there was still insufficient information on abundance, stock relationships, life history and feeding ecology to go forward with the requested assessments for these species. This may become feasible once further abundance estimates from the Icelandic and Faroese areas are produced, and the ecological studies in the Faroes, Iceland and Norway are completed. The Scientific Committee recommended that these studies be completed in a timely manner

GREY SEALS

In 2002 the Council requested that the Scientific Committee provide a new assessment of grey seal stocks throughout the North Atlantic. Dr. Kjell Nilssen has accepted the position of chairman of the new Grey Seal Working Group. The general terms of reference of this Working Group will be:

- to assess the status of grys seals around Iceland, the UK, the Faroes, Norway, the Russian Federation, the Baltic, Canada and other areas;
- survey methods;
- stock delineation (genetics, temporal and geographical distribution);
- recommendations.

It was decided that the meeting should be held in early April in Iceland. As surveys for this species are being conducted in Iceland and Norway in 2002, and due to other international meetings with overlapping agendas it was not considered feasible to schedule a meeting for this WG earlier than this.

HUMPBACK WHALES

In 2002 the Council recommended that the Scientific Committee complete abundance estimates for this species as a high priority, and should also consider the results of the "Years of the North Atlantic Humpback" (YoNAH) project as it pertains to member countries in providing advice for this species.

The Scientific Committee noted that abundance estimates are being completed for this species as a high priority. New abundance estimates from the NASS-2001 aerial and ship surveys are presently under development and there is evidence from the Icelandic aerial surveys that the stock is increasing at a rapid rate in that area. There has also been an increase in both incidental and survey sightings around the Faroes. The aerial digital photographic survey being conducted in West Greenland should provide an estimate of abundance in that area. Efforts to obtain photographs and biopsy samples from eastern Icelandic waters were continuing, as had been recommended last year. In Greenland, 4 satellite tags have been successfully deployed on humpback whales this year.

Information from the YoNAH project, pertaining to stock delineation, migration, biological parameters, and abundance both North Atlantic-wide and in feeding areas has been published. The Scientific Committee has noted previously (2001) that estimates from the NASS-95 survey appear to conflict with the results of the YoNAH project, and comparison with the estimates from NASS-2001 should be of great interest.

NORTH ATLANTIC SIGHTINGS SURVEYS

NASS-2001

Minke whales

Analysis of data from the Faroese and Icelandic ship surveys is presently in progress. A preliminary estimate from the aerial survey around Iceland has been completed, and the final analysis is being conducted by a contractor. An analysis of trends in distribution and abundance of minke whales from aerial surveys conducted in the coastal waters of Iceland in 1986, 1987, 1995 and 2001 showed that the distribution of

minke whales was very stable from year to year, with highest densities in the SW, N and SE waters of Iceland. Relative abundance showed a significant increase in the area to the N of Iceland, and moderate but non-significant increases in the high-density area in SW Iceland (Faxaflói), NW Iceland and in the survey area as a whole, over the period. The Scientific Committee concluded that the abundance of minke whales around Iceland has been stable or shown a moderate increase over the period, and that the apparent increase in relative abundance in the area to the N of Iceland is consistent with population growth after cessation of catching.

Fin whales

An abundance estimate of 25,352 (95% CI 19,579 to 32,831) from the ship survey around Iceland and the Faroe Islands was accepted by the Scientific Committee. This is higher and more precise than estimates from equivalent areas from past NASS surveys. While some of this increase may be related to increases in survey efficiency, this factor alone likely cannot explain the observed increase since 1987. Stock increase, immigration from other areas, and/or variation in distribution between years may also be involved. The four NASS ship surveys carried out since 1987 provide an excellent time series of abundance for this species. It was therefore recommended that a more complete analysis of changes in abundance over all the NASS surveys be conducted. This may require some re-analysis of past survey data as the coverage has changed between surveys.

Humpback whales

A preliminary line transect estimate for humpback whales from the 2001 Icelandic aerial survey has been completed, resulting in and estimate of 3,057 (95% CI 1,727 - 5,410) for the area. However this estimate has a negative bias because of animals missed by the observers and, probably more importantly, animals missed because they were diving when the plane passed.

Sightings from the NASS-2001 ship survey were highly clustered around NE and W Iceland within the aerial survey block, but substantial numbers were also seen in areas farther offshore. More sightings were made in the Faroese block than in previous surveys. An analysis of these data and from the 1995 survey is presently being conducted by a contractor.

An analysis of the trend in sighting rate over the course of the 4 Icelandic aerial surveys carried out since 1986 showed an increase of 11.4% (SE 2.1%) per year over the period in the survey area. This rate of increase is in accordance with that of 11.6% over the period 1970 - 1988 in recorded sightings of humpback whales by whalers operating west of Iceland. There has been almost no catch of humpback whales around Iceland since the first stage of Icelandic whaling came to an end in 1915. Therefore, stock recovery is one plausible explanation for the trend, however the observed rate is on the edge of biological plausibility. Immigration from other areas may also be playing a role.

Lagenorhynchus dolphins

A preliminary abundance estimate for the Icelandic aerial survey has been completed, resulting in an estimate of 20,444 (95% CI 12,714 - 32,874). This estimate is biased downwards both by animals missed by observers and animals that were underwater when the plane passed over.

Analysis of the ship survey data from 2001 and earlier surveys is considered problematic because of uncertain species identification, uncertain group size estimation, and possible responsive movement of these species.

Sperm whales

A calculation of sperm whale abundance from the 2001 Icelandic and Faroese shipboard surveys, using a combination of cue-counting and line transect methodologies, resulted in an estimate of 11,185 (CV 0.34) for the area. However this estimate is heavily dependent on estimates of the proportion of the time the

whales spend at the surface, and the frequency of deep dives, for which there is no data for the survey area. Once these data are collected, probably through radio-tagging studies, the estimate can be revised.

Other species

The Scientific Committee considered that, in addition to the species already mentioned, abundance estimates from the ship survey were feasible for pilot whales and bottlenose whales. These analyses should be completed in the coming year. For other species, such as killer whales and blue whales, the data are not suitable for the estimation of abundance, but general descriptions of distribution will be produced.

Evaluation of survey methodologies

The Working Group provided a detailed evaluation of the methodologies used in the ship and aerial surveys, and a list of recommendations for improvements. The Scientific Committee considered that the Report and the contributory working papers should serve as an excellent guide for the planning and conduct of future NASS surveys.

Future work

The Scientific Committee agreed that completion of the following analyses should be of high priority:

i. Aerial survey estimate of minke whales around Iceland from 2001 and 1987, accounting for bias due to measurement error and whales missed by observers. This work is presently being pursued under contract.
ii. Spatial analysis of humpback whale distribution and abundance, from 2001 and 1995 ship and aerial surveys. This work is presently being pursued under contract.
iii. Abundance estimate of minke whales from Faroese and Icelandic ship surveys, 2001. This is in progress;
iv. Abundance estimates for dolphins from the 2001 and earlier surveys;
v. Abundance estimates for pilot whales and northern bottlenose whales from the 2001 survey.

It was anticipated that all or most of this work could be completed in time for a meeting of the Working Group early in 2003.

Status for analyses and publications from previous NASS surveys

Although the idea of publishing a volume on the North Atlantic Sightings Surveys (NASS) was dropped in 2000 by the Scientific Committee, it was revived in 2001 following the NASS-2001 survey. The Scientific Committee agreed that a special volume on the NASS surveys in general would be of great interest to many researchers. Four NASS surveys have been conducted, over a long enough time frame that temporal trends in distribution and abundance may be detectable. The volume therefore should not merely report abundance estimates from the later surveys, but should synthesise results from all the NASS surveys to elucidate temporal and spatial patterns. It was considered that the volume could best be organised by species, with contributors using information from all the NASS surveys regardless of national affiliation.

It was agree that Dr Nils Øien and Daniel Pike would edit the new volume. Given the amount of work that remains to be done, this volume will not be completed before sometime in 2004.

PROVISION OF ADVICE ON SUSTAINABLE CATCH TO COUNCIL

The Scientific Committee considered ways in which it could improve and enhance the provision of its advice on sustainable catch to the Council. A review of requests for advice from the Council shows that they have varied quite widely, ranging from general requests for stock assessments, to requests mentioning specific potential catch levels. It was apparent that more specific and detailed requests for advice from the Council resulted in more useful advice from the Scientific Committee. The Scientific Committee agreed that the explicit statement of management goals was one of the most important considerations in providing high quality scientific advice on sustainable catch. Requests for advice on catch levels should contain a minimum

of information about management goals and timelines so that they can be responded to effectively. It was agreed that a Correspondence Group should be established to provide guidance to the Council in the most effective formulation of requests for advice, and report back to the Committee in advance of the next meeting of the Council.

Relatively few organizations involved in fishery management actually use a well-defined management procedure, the prime example being the Revised Management Procedure (RMP) developed by the IWC. While the use of an explicit and documented management procedure or procedures would have some advantages for the Scientific Committee and NAMMCO as a whole, the Committee considered that the wide range of species and harvesting activities subject to NAMMCO advice, and the lack of clear and explicit mangement goals, would make development of a single or even multiple management procedures difficult or impossible for NAMMCO. The Committee considered that one of the main problems with the use of explicit management procedures such as the RMP was the lack of flexibility in adapting to different management goals and different types of fisheries. While part of the intention in developing such procedures was to reduce the workload on the committee providing advice, experience with the RMP had shown that this was not necessarily the end result. The Committee was also concerned that once an explicit management procedure is adopted at the political level, it can be difficult to change some of the parameters and assumptions of the procedure even if they are demonstrated to be false.

The Scientific Committee favoured an approach where advice on catch levels is presented in a form that shows the probability of achieving desired stock trajectory under different catch options, with a full evaluation of the uncertainty of the predictions, if sufficient data are available to support such an assessment. The advice provided for West Greenland beluga is one example of this approach. In conducting assessments, it is also advantageous to use more than one assessment model if available, as this increases confidence in the results.

NAMMCO SCIENCE FUND

At the 9th meeting of the NAMMCO Council in 1999, the Chairman of the Scientific Committee, Dr Mads Peter Heide-Jørgensen, proposed that the Scientific Committee be given the option of conducting its own research with funding provided by the Council. Subsequently the Scientific Committee developed a full proposal for such a Science Fund, with 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. The proposal for the Science Fund, along with these examples of projects that could be conducted under the program, was presented to the Council at their 11th meeting in February 2002. The Council decided not to support the establishment of a NAMMCO Science Fund. The Council did however acknowledge that a better way must be found to convey the priorities of NAMMCO to National Research Institutions.

The Scientific Committee expressed its profound disappointment that a Science Fund could not be established. As the intention of the Fund was to fund research that would facilitate and accelerate the response of the Scientific Committee to requests put to it by the Council, the Committee noted that its recommendations for research must be acted upon by national research institutes if the requests of the Council are to be fulfilled in a timely manner.

PUBLICATIONS

Three volumes of NAMMCO Scientific Publications have now been published: Vol. 1 *Ringed seals in the North Atlantic*, Vol 2 *Minke whales, harp and hooded seals: Major predators in the North Atlantic ecosystem,* and Vol. 3 *Sealworms in the North Atlantic: Ecology and population dynamics*. The latter was published late in 2001 and has been distributed to libraries, research institutions and to journals for review.

The following volumes are presently in progress: Vol. 4 *Belugas in the North Atlantic and the Russian Arctic***.** ed. Heide-Jørgensen, M.P. and Wiig, Ø. which should be published in October; Vol. 5 *Harbour porpoises in the North Atlantic* (no title chosen yet). ed. Haug, T., Desportes, G., Víkingsson, G. and Witting, L., which should be out early in 2003. In addition the Scientific Committee has decided to proceed with a volume on the North Atlantic Sightings Surveys (see above)

FUTURE WORK PLANS

It was decided that Greenland shall host the next meeting of the Scientific Committee in November 2003, at a location yet to be determined.

At least 4 working groups are expected to be active in 2003: Grey Seals, Abundance Estimates, North Atlantic Fin Whales and North Atlantic Minke Whales. In addition two new groups will meet by correspondence: Satellite Tagging and Advice Requests. Given the number of meetings and the fact that some contract work will be necessary to support these activities, costs might exceed the usual budget allocation of the Scientific Committee.

ELECTION OF OFFICERS

Gisli Víkingsson was elected as chairman for an additional year, and Lars Walløe was elected as vice chairman.

REPORT OF THE TENTH MEETING OF THE TENTH 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 10th meeting (Appendix 1), held at the whaling station at Hvalfjörður. He noted that Lars Walløe had replaced Dr Nils Øien on the Committee. On behalf of the Scientific Committee Víkingsson expressed his thanks to Dr Øien for his great contribution to the scientific work of NAMMCO, and welcomed Lars Walløe to the Committee. Members Mads Peter Heide-Jørgensen and Christian Lydersen did 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 2001 from the Faroes, Greenland, Iceland, and Norway were presented to the Committee.

4.2 Working Group Reports and other documents

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

5. COOPERATION WITH OTHER ORGANISATIONS

5.1. IWC

The 54th meeting of the Scientific Committee of the International Whaling Commission was held in Shimonoseki, Japan, from 25 April to 11 May. Daniel Pike attended as observer for the NAMMCO Scientific Committee.

An Implementation Review for North Atlantic minke whales was scheduled for this year. However the Norwegian authorities were not able to provide the required data and estimates of abundance for Northeast Atlantic minke whales 3 months in advance of the Scientific Committee meeting, as stipulated under the Revised Management Procedure. Therefore the Implementation Review will be continued in 2003. Information on minke whale abundance from the 1996 - 2001 survey period was presented to the Scientific Committee. The abundance estimate for this period was substantially lower than that for 1995. Information on minke whale genetics, dive times and ageing was also presented to the Scientific Committee.

The comprehensive assessment of North Atlantic humpback whales was continued from last year. This year new information on abundance around Iceland from the NASS-95 survey, and trend in abundance from the NASS aerial surveys (1986-2001) and observations from whalers (1956-1985), was used in the assessment. The assessment model was also further developed. The new assessment model was again unable to reconcile all the available data, and predicts that the population should have reached carrying capacity by now. However it still appears to be growing in some areas.

The Committee considered that an increase in the take of humpback whales by St Vincent and the Grenadines from 2 to 4 whales was unlikely to have an impact on the population, assuming that the whales found in the Eastern Caribbean are part of the West Indies breeding stock.

Survey reports from the NASS-2001 shipboard and aerial surveys around Iceland were presented to the Committee. In addition, abundance estimates for fin and sperm whales were presented. The Committee did not have time to fully consider these reports. However, the Committee noted that the sharing of platforms with an international redfish survey had been successful during NASS-2001, and recommended that nations participating in the redfish survey incorporate a cetacean survey.

Work on the Aboriginal Subsistence Management Procedure continued, and the Committee selected a strike limit algorithm (SLA) for the Bering-Chukchi-Beaufort bowhead whale stock. The Committee is now moving ahead with trials of SLA's developed for Eastern Pacific gray whales.

The Committee discussed plans for a new aerial survey off Greenland for minke and fin whales to be carried out in 2002. The survey will use digital photography in a strip transect design.

The third circumpolar series of IWC-SOWER sighting surveys (CPIII) in the Southern Ocean will be completed this year. Results to date indicate that abundance from CPIII is about 46% of that from CPII, a significant decrease. Many possible reasons for this apparent decrease were discussed, including real population change, lower g(0) in later surveys, and an increase in the proportion of animals in areas not surveyed, especially pack ice areas. No consensus was reached, and the evaluation will continue next year.

The Committee decided to begin an in-depth assessment of sperm whales, and established an intersessional working group to begin planning.

The Scientific Committee conducted a very extensive review of the proposed JARPN II research program by Japan, which involve lethal sampling of up to 150 minke whales, 50 Brydes whales, 50 sei whales and 10 sperm whales annually, according to guidelines previously set for such reviews. In addition the Committee conducted a scheduled review of the Indian Ocean Sanctuary.

5.2 ICES

Haug reported on recent developments in ICES. One ICES committee that deals with marine mammals as an important issue is the Living Resource Committee (LRC). 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 Ecosytems” and ”Monitoring Techniques and Estimating Abundance of Seals”.

The ICES Working Group on Marine Mammal Population Dynamics and Habitats (WGMMPH), met in May 2002 by correspondence to develop further the basis for advice, following a request from the European Commission, on cetacean bycatch and bycatch mitigation measures in European Union fisheries. Information on by-catches of cetaceans in various gear types were reviewed and possible limitations in use of gear and time/area closures discussed. Questions concerning the use of pingers, gear modifications, and other mitigation measures were addressed. WGMMPH will meet again in March 2003 to address issues such as bycatches of marine mammals in fisheries, the role of seal epizootic events in population regulation, census techniques used in seal abundance estimation, and the effects of expanding seal populations.

The Scientific Committee noted the continuing overlap of interests between NAMMCO and ICES, particularly with regard to harp, hooded and grey seals, and bycatch issues with small cetaceans, and urged scientists from member countries to participate in the ICES working groups to the extent feasible.

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

Neither the Joint Commission or the Scientific Working Group has met since the last meeting of the Scientific Committee. Witting has been appointed chairman of the Scientific Working Group, and indicated that the next meeting would be held jointly with the NAMMCO Scientific Working Group on the Population Status of North Atlantic Narwhal and Beluga if feasible.

6. INCORPORATION OF THE USERS KNOWLEDGE IN THE DELIBERATIONS OF THE SCIENTIFIC COMMITTEE.

Grete Hovelsrud-Broda (General Secretary to NAMMCO) reported on the upcoming NAMMCO Conference on User Knowledge and Scientific Knowledge in Management Decision Making to be held in Reykjavik, Iceland 4 – 7 January 2003. The overall goal of the Conference is to find ways to incorporate the knowledge of users (whalers, sealers and fishermen) into the management decision-making process in parallel with science. The idea for the Conference emerged from the apparent disagreement between the users on the one hand, and the scientists on the other with respect to, for example, the actual numbers of animals (and fish) found in an area, their migratory routes, feeding habits and biology. Management decisions are predominantly based upon the western-based knowledge system of science, although co-management programs exist. While marine resource management has great impact on the resource users, their knowledge is not included in the same manner as science in management decisions. The two knowledge systems differ in a number of ways, and the conference will compare and contrast these in terms of how the knowledge is gathered, stored, used and transmitted. Thus the Conference will compare the foundation of the two systems of knowledge in relation to resource management, of in particular, marine mammals. The speaker list includes scientists, users and managers. The topics will focus on experience from existing projects, the foundations of user and scientific knowledge, a comparison of the two, the management decision making process in terms of the information sought in management decisions, and the process of drafting regulations, and the role and application of user and scientific knowledge. The Conference will also include two discussion sessions between panellists and the open forum of participants. A drafting group will be established to assess the similarities and differences between the systems of knowledge, and if the meeting so decides will draft a set of recommendations on how to move forward in incorporating user knowledge in the management decision making process. The Secretary urged the Scientific Committee members to attend the Conference.

The Scientific Committee supported this initiative and urged members to attend if possible. It was suggested that the inclusion of input from fisheries science and management, which have a long history in this area, would be useful.

7. 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 been delayed pending the outcome of a NAMMCO conference on this topic (see Item 6). Also, these reports will have to be updated to incorporate new results from NASS-2001, and a pending assessment by NAMMCO for minke whales.

Pike reported that he had completed a draft of the Stock Status Report for ringed seals, and provided it for the review of the Scientific Committee. Work on other reports has been delayed due to competing priorities, but the next priorities for completion will be walrus, beluga and fin whales. It is anticipated that the first 3 stock status reports (minke whales, pilot whales, ringed seals) will be placed on the NAMMCO web site in fall 2002.

The Scientific Committee reiterated the importance of completing these documents, and suggested that members having a special interest in certain species could complete the initial draft for those species. For other species, the idea of contracting out production of the reports should be considered. Pike agreed to provide interested members with the format of the stock status reports, and to look into the idea of contracting the production of reports for species for which there is no special expertise on the Committee.

8. ROLE OF MARINE MAMMALS IN THE MARINE ECOSYSTEM

8.1 Working Group on Marine Mammal - Fisheries Interactions

Background

At its 8th meeting, the NAMMCO Council tasked the Scientific Committee with providing advice on the economic aspects of marine mammal-fisheries interactions. A Working Group on the Economic Aspects of Marine Mammal - Fisheries Interactions met in February 2000 to consider parts 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 a workshop to further investigate the methodological and analytical problems in estimating consumption by marine mammals. This workshop was held in Tromsø in September 2001 and resulted in, among other things, a list of research priorities to refine existing estimates of consumption by North Atlantic marine mammals (NAMMCO 2002).

The Scientific Committee viewed the next logical step in this process to be a review of how presently available ecosystem models can be adapted in order to increase our understanding of and quantifying marine mammal - fisheries interactions. Several different candidate models had been identified: the Icelandic BORMICON/GADGET, the Norwegian MULTSPEC and Scenario Barents Sea, and ECOPATH/ECOSIM. The Workshop was held in Reykjavik in September 2002. It was tasked with choosing a preferred modelling approach for analysing the ecological role of minke whales, harp and hooded seals, and other marine mammal species in the North Atlantic, identifying required input data, and recommending a process for further development. The Working Group was not expected to review results or make quantitative predictions at the meeting, but rather to focus on methodological problems.

The Scientific Committee of the International Whaling Commission had held a workshop on a similar theme in La Jolla, California in June 2002. Some of the results from the IWC meeting were summarised for the Working Group. A general conclusion from the IWC meeting was that interactions between marine mammals and fish species are a topic worthy of quantitative scientific investigation. The IWC workshop investigated several candidate modelling tools, including MULTSPEC and ECOPATH/ECOSIM.

Available multi-species models

The Working Group considered descriptions of the range of available multi-species modelling tools. This includes two general classes of models typified by the Minimum Realistic Models (MRM) on the one hand and the ECOSIM/ECOPATH approach on the other. The MRM class includes MULTISPEC, BORMICON/GADGET and Scenario Barents Sea. These models share the characteristics of being system specific, modelling only a small component of the ecosystem for a specific purpose, and treating lower trophic levels and primary production as constant or varying stochastically. In contrast,

ECOPATH/ECOSIM is an all-inclusive approach that incorporates lower trophic levels and primary production.

MULTSPEC, which was established at the Institute of Marine Research in Bergen, is a general-purpose multi-species simulator for the Barents Sea. It was initially designed to be a tool for calculating the spawning biomass of capelin, but later interactions between fish and marine mammals were included. At present the species capelin, cod, herring, polar cod, minke whales and harp seals are modelled.

When marine mammals were added to the fish species some rather counter-intuitive results were obtained. There proved to be a larger gain in the cod fishery by removing the seal population from the model than by removing the whale population, even if the whales eat more cod. Also, decreasing the suitability of herring as food for cod had a larger effect on the yield from the fisheries than removing the marine mammals altogether. The reason for this lies with the cod-herring-capelin dynamics. In order to get the marine mammals – fish interactions right the fish-fish interactions must be right. At present MULTSPEC is resting and there has not been active work on this model for several years due to lack of resources.

Scenario Barents Sea is a series of projects at the Norwegian Computing Center in Oslo with extensive help and advice from Institute of Marine Research in Bergen and Tromsø. The two first projects were carried out from 1993 to 1999, while a new project funded by the ministry of Fisheries will be carried out in the period 2002-2004.

The previous projects compared management strategies for cod and herring (Hagen *et al* 1998); studied among other things the direct and indirect effects of minke whale abundance on cod and herring fisheries (Schweder *et al.* 2000a), and also compared management strategies with respect to long term resource rent, harvest capacity, catch, and abundance of cod (Schweder *et al.* MS 2000b).

When studying the interaction between management of marine mammals and fish, the model in the previous projects includes 4 species: cod, capelin, herring and minke whales. The catch of cod was estimated to increase by some 6 tons with the removal of every minke whale from the populationl. Schweder *et al* (2000a) found further that minke whale abundance affects the cod fishery in a linear fashion over a wide range of minke whale abundance. The results concerning the effects on the cod and herring fisheries must be taken as tentative since the ecosystem model used could be improved, and so could the strategies for managing the fisheries.

In the new project harp seals will be included in the model. The aim is to study how various management strategies for marine mammals will affect the Norwegian fish-fisheries, on the basis of our current knowledge and data concerning the population dynamics of, and interaction between, harp seals, minke whales, cod, herring and capelin. Another aim is to identify gaps in our knowledge, and pressing data needs. A long term goal is to transport the various components of the model to the system GADGET, and to build the model further in this system.

BORMICON (A BOReal MIgration and CONsumption model) was a multi-species, spatially disaggregated model initially developed for Icelandic waters. It took into account growth as a function of consumption and allows the user to specify their preferred likelihood functions. The current program, GADGET (Globally Applicable Area-Disaggregated Generic Ecosystem Evaluation Tool), is a fully parametric forward simulation model (and can therefore in principle be run without any data). A simulation results in population trends by species, size class, age group, area and time step. These trends can subsequently be compared to data using appropriate likelihood functions, eventually maximising the likelihood functions to obtain parameter estimates. Consumption within GADGET is modelled using suitability functions and mortality can be either due to predation, other natural causes or fishing.

The Working Group was impressed with the scope and ambition of this project in attempting to establish a framework for ecosystem models of various levels of complexity. When put to use, the GADGET system will provide a strong and unified platform for data handling, scenario modelling and simulation, and model fitting. Such a unified platform is certainly welcome, and so is the information technology that is brought together in GADGET. However, even with as good information technology as GADGET, it must be remembered that GADGET is a platform upon which models can be built. Scenario- and assessment models are necessarily case specific, and all the specifics needs to be worked out in each particular case. It was noted that marine mammals have not been included in any of the GADGET case studies to date. The project has limited funding, and will not accomplish much more in the time left beyond putting together the currently available data and knowledge in the existing framework.

ECOPATH is an equilibrium approach to multi-species modelling. Mass balance equations are used, essentially relating production by some species to predation by others under the assumption that the system is in a steady-state. Unlike the models discussed above, ECOPATH also considers the lower trophic components of the ecosystem, e.g. plankton. ECOSIM builds upon this approach, but drops the equilibrium assumption so that the system is modelled by a set of coupled differential equations. Potentially ECOSIM could provide a basis to provide advice on marine mammal-fisheries interactions. An advantage of the package is the structured framework it provides to setting out species-specific inputs required for multi-species modelling. Potential disadvantages discussed included the in-built functional forms for species interactions, and simplified treatment of age-structure, that may not be appropriate for the particular cases to be considered. Another problem is the large number of parameter values that need to be specified; some of these may have an appreciable impact on outputs, and the default suggestions provided by the package may not be the most appropriate in all circumstances.

Prey selection processes

To elucidate the prey selection function of minke whales, Norwegian Institute of Fisheries and Aquaculture performed studies of minke whale foraging dynamics in selected areas in the southern Barents Sea in 1998 and 1999. Stomach contents were sampled onboard commercial whaling vessels whereas the resource availability was assessed using standard acoustic surveys by research vessels.

Studies of the type presented provide estimates of prey selectivity at the microscale. However, multi-species models require estimates of such consumption functions at the macroscale (the spatio-temporal scale of the strata adopted for the population dynamics modelling). Conversion of the results from microscale experiments on selectivity to yield macroscale estimates is not straightforward, as the results will depend on the spatio-temporal distributions of predators and their different prey species, and the former may alter in response to changes in the latter.

There is a rich economic literature on human choice- and consumer behaviour, and there is a wealth of experience in estimating models on both the individual level and on the aggregated level. The economic paradigm of rationality is that humans make their choices on the basis of utility maximisation within the options available in the situation, and under budget constraints. A weak form of this paradigm might also be used when modelling animal behaviour on the micro level.

Recommended modelling approach for NAMMCO

Considering the data available or likely to become available in the foreseeable future, the Working Group favoured the approach of using a limited model that encompassed only the major species of interest, as opposed to an all-encompassing model where all or most species are included, as a basis for potential management advice in the short to medium term. This approach can be described as a Minimum Realistic-type model, as exemplified by Scenario Barents Sea, MULTSPEC and BORMICON. Other components of the ecosystem that are not explicitly modelled, such as primary production or zooplankton, could be left as constant, allowed to vary randomly or linked to environmental covariates.

Some members voiced the concern that the development of ecosystem models without sufficient data in some components would produce results that might be used by inappropriately by managers, who might not understand the level of uncertainty in the results even if it is specified. It was suggested that it would be better to wait until the required data is gathered before proceeding to ecosystem modelling. Other members noted that even models in which some components are parameterised with "plausible ranges" can be useful in determining the sensitivity of the model to variation in parameters, and thus in determining the most important gaps in knowledge. It was agreed that the two activities should proceed simultaneously: that is, the data gaps identified should be filled by dedicated studies, while modelling can proceed in candidate areas, even with partial data, as long as the uncertainty of the results is emphasised and integrated in the results. In this way, modelling approaches can be refined and the reliability of the results will improve as more data is gathered.

There was agreement that the continued development of the Scenario Barents Sea model should be a priority, with emphasis on incorporating the predation of harp seals in the model. In addition the Working Group recommended the development of a second, more general North Atlantic "template" model based on the GADGET platform. This spatially homogeneous model would include species important in candidate applications to West and East Greenland, Iceland and the Barents and North Seas. However the abundance of these species would be varied between the areas according to available information. The quality of the available input data varies greatly between areas, and in cases where little information is available, plausible ranges would be used. It will be crucial to capture the full range of uncertainty in these ranges. In areas where data is lacking, such as West Greenland, the main use of such a model will be to identify the sensitivities to variation in input parameters, and thus to assist in the setting of priorities for research. In Icelandic waters, where better data is available for fish but data on marine mammal diets and prey selection are scarce, such a model will serve the same purpose but also generate preliminary scenario results for management. For the relatively data-rich Barents Sea area, the model will augment the main Scenario Barents Sea modelling effort.

In reviewing the amount of multi-species modelling work and associated applications to management decisions that had been conducted world-wide over the past several years, the Working Group noted a much lower than expected activity in this area. This was considered surprising given the emphasis politicians and management authorities have placed on multi-species (ecosystem) approaches to the management of marine resources. While the principle of multi-species management seems to be widely accepted, the practical aspects of putting it into practice lag far behind the rhetoric. The Working Group emphasised that progress in this area will not be made unless significant additional resources are dedicated to it.

Research needs

The Working Group reiterated the research priorities identified by the NAMMCO Scientific Committee in 2001 (NAMMCO 2002). In particular the Working Group emphasised that additional information on harp seal diet and consumption in the Barents Sea is a priority to further the modelling work. The functional nature of prey selection by marine mammals under varying levels of prey abundance and from mixtures of available prey was also considered a priority for further research. To derive these functions diet data must be collected in conjunction with resource surveys at appropriate temporal and spatial scales. In addition the Working Group identified the following priorities:

Prey selection:

- theoretical and practical work on prey selection models
- development aggregated consumption functions
- migratory and spatial aspects of consumption models

Multi-species modelling:

- Further work on the Scenario Barents Sea model
- Use GADGET as a framework to generate template models for candidate areas in the North Atlantic

It was considered that discussion of the economic aspects of marine mammal-fisheries interactions would be premature until at least one of the two models above has been developed. Once models are available that can predict the variation in target species in response to management measures, linkages to simple economic models that assess the economic consequences of the responses can be made.

General discussion

The Scientific Committee supported the conclusion of the Working Group that progress in the development and application of multi-species approaches to the management of marine resources was lagging far behind the stated need of management agencies for such approaches, and again emphasised that progress in this area will not be made unless significant additional resources are dedicated to it.

The Scientific Committee considered that it may have identified a way forward in addressing the requests from the Council, but stressed the importance of completing the necessary modelling work and collection of required input data before further progress on this matter can be made. For the modelling work, further progress cannot be made outside of the Barents Sea candidate area without additional resources, and the modelling effort for the Barents Sea could be enhanced with additional funding and manpower. Priorities for the collection of input data have been identified previously (NAMMCO 2001, 2002) but it cannot be expected that these data gaps can be filled within a short time frame, even if new resources are dedicated to the activity. If new resources are not available, the required input data cannot be collected and it will not be possible to provide the advice to the Council.

Witting, however, pointed out that even if required data should be collected, Minimum Realistic Models might not be able to realistically project the effects of an increased or decreased harvest of marine mammals. He argued that to firmly analyse the ecological effects of changes in the harvest of marine mammals a detailed understanding of the predator prey and competitive interactions of all relevant species is needed including a description of the density and prey dependent changes in the consumption functions of all species. While models that include all these interactions may, in principle, be able to predict the ecological impact of changed harvest levels, they represent unrealistic modelling approaches because it will be essentially impossible to estimate all the parameters. For most cases, he therefore found that it is unwise to base management on the predictions of multi-species models, although he agreed that these models are needed for a more basic scientific level in order to obtain a better understanding of various ecosystems.

While there was some disagreement as to the suitability of minimum realistic models in general for providing management advice, it was agreed that this type of model was superior to the available alternatives. The Scientific Committee will assess any future modelling efforts critically with regard to the quality of input data, modelling assumptions and realism before deciding if any advice can be given.

The Scientific Committee agreed that the next meeting of the Working Group should focus on assessing modelling results from the Scenario Barents Sea model and possibly the GADGET-based template models for other areas, if they are developed. The Working Group should also consider the feasibility of connecting the multi-species models with simple economic models at that time. Walløe agreed to provide the Scientific Committee with a report on progress in the modelling efforts identified by the Working Group at next year's meeting. The Scientific Committee will assess progress made in modelling and in the collection of input data and decide at that time whether enough progress has been made to warrant another meeting of the Working Group.

8.2 Other matters

Document SC/10/16 described a project, initiated by members of the NAMMCO Scientific Committee, to enable an assessment of the ecological role of harp and hooded seals throughout their distributional range in the Nordic Seas (Iceland, Norwegian, Greenland Seas). The project pays 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. To provide data, seals were collected for scientific purposes on expeditions with R/V"Jan Mayen", conducted in the pack ice belt east of Greenland in September/October 1999 (autumn), July/August in 2000 (summer), and February/March in 2001 (winter). Results from analyses of stomach and intestinal contents from captured seals in this particular habitat, which is only a small part of the distributional range, revealed that the diet of both species were comprised of relatively few prey taxa. Pelagic amphipods of the genus *Parathemisto* (probably almost exclusively *P. libellula*), the squid *Gonatus fabricii,* the polar cod *Boreogadus saida*, the capelin *Mallotus villosus*, and sand eels *Ammodytes* spp were particularly important. Although their relative contribution to the diet varied both with species and sampling period/area, these five prey items constituted 63-99% of the observed diet biomass in both seal species, irrespective of sampling period. For the hooded seals, *G. fabricii* was the most important food item in autumn and winter, whereas the observed summer diet was dominated by polar cod, however with important contribution also from *G. fabricii* and sand eels. The latter were observed on the hooded seal menu only during the summer period, while polar cod, which contributed importantly also during the autumn survey, was almost absent from the winter samples. During the latter survey, also capelin contributed to the hooded seal diet. *Parathemisto* was most important for the harp seals during summer and autumn, whereas in winter the contribution from krill, capelin, and some other fish species were comparable and even larger. Harp seals appeared to consume some *G. fabricii* at all sampling periods, whereas polar cod, taken mainly in summer and autumn, was replaced by capelin and other fish species on their menu in winter.

A final survey within the framework of the project will be conducted using R/V"Jan Mayen" in pack ice waters off the east coast of Greenland in September-October 2002. Additional to the dedicated surveys, samples for the project have been obtained from local hunters operating on the east coast of Greenland and from animals taken in bycatches and hunt in Icelandic waters.

Mikkelsen reported that the sampling program for dolphins taken in drives was continuing, and that significant numbers of samples from white-sided dolphins had been collected this year. It is expected that diet and life history analyses will be conducted in the coming year. Víkingsson reported that analysis of samples of white-beaked dolphins from Icelandic bycatch was nearly complete, and that he expected to report the results in the coming year. The Scientific Committee encouraged the timely completion of these programs and the publication.

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

9.1 and 9.2 Harp and hooded seals

9.1.1 Update on progress

Haug provided a progress report on an aerial survey for harp and hooded seals in the Greenland Sea which took place during the period 14 March to 6 April 2002. In the Greenland Sea, harp and hooded seals were surveyed by air in 1991 and 1997, respectively. Although not formally established, it has been argued that the period between surveys should not exceed 4 to 5 years. For this reason, new aerial surveys to assess the status of the Greenland Sea population of harp seals and, if possible, hooded seals during their whelping period (March-April) were conducted in 2002. During field work, which included participation of Canadian scientist with substantial experience from similar surveys in the Northwest Atlantic, it soon became evident that logistical restrictions in combination with unusually scattered and wide distribution of the hooded seal pups made it impossible to survey both species simultaneously. Therefore, the survey focussed on harp seals.

One fixed-wing twin-engined aircraft was used for reconnaissance flights and photographic surveys along transects over the whelping patches once they had been located and identified. A helicopter, stationed on and operated from the applied research vessel (R/V"Lance"), assisted in the reconnaissance flights, and subsequently flew visual transect surveys over the whelping patches. The helicopter was also used for other purposes, such as age-staging (also performed along transects over the patches) of the pups to assess the temporal distribution of births. Three harp seal breeding patches were located and surveyed either visually, photographically or both. Analyses of images from the photographic surveys are still in progress. These analyses include participation of Canadian and Russian scientific personnel with experience from similar analyses from harp seal surveys in the Northwest Atlantic and White Sea, respectively. The results from the aerial surveys will be used to estimate the total 2002 harp seal pup production. Subsequently, the status of the stock will be assessed by fitting population models to the pup production estimate.

The Scientific Committee noted the effort to calibrate analysis of the photos between laboratories, and suggested that this was an excellent approach that should be followed for other surveys.

Witting noted that the aerial digital photographic survey off Greenland would produce data on the distribution and abundance of harp seals in open water in that area.

9.1.2 Future work

In a meeting in the ICES Headquarters, Copenhagen, in October 2000, the Joint ICES/NAFO Working Group on Harp and Hooded Seals [WGHARP] decided to arrange a workshop to examine methods of modelling of pinniped populations, with specific focus on North Atlantic harp and hooded seal populations. The group has so far been unable to assess existing pinniped population models and decide upon a standardised series of models. At the workshop, a variety of population models are to be presented and their performance evaluated under different scenarios concerning the availability of data and the degree of uncertainty expected. WGHARP recognises that as more information becomes available on the various harp and hooded seal stocks there will be an increased need to standardise a suite of population models that can most effectively accommodate the range and type of data collected. Topics of the workshop will include, but not necessarily be limited to:

- A review of existing WGHARP models;
- Comparison of other modeling regimes (e.g., the International Whaling Commission's Revised Management Procedure and the US Marine Mammal Protection Act) to the current WGHARP approach.
- Approaches to the incorporation of density dependence into pinniped models.
- Use of simulation to test the assumptions implicit in model parameters.
- Comparison of age-aggregated versus desaggregated models, especially under scenarios where the age structure of the catch is highly skewed.
- Consider the applicability of biological reference points.

Named the " Workshop to Develop Improved Methods for Providing Harp and Hooded Seal Harvest Advice", it will be held at the US National Marine Fisheries Science Center in Woods Hole, MA, USA, on 11-13 February 2003 under the convenorship of one of the WGHARP members, Richard Merrick from the US National Marine Fisheries Science Center.

WGHARP has not met since October 2000, but is due to meet in Arkhangelsk, Russia from 1–5 September 2003 to:

- review of recommendations from the "Workshop to Develop Improved Methods for Providing Harp and Hooded Sea Harvest Advise", possibly also apply recommended models to existing data on harp and hooded seals;
- review and discuss existing methods applied in seal diet and consumption studies;
- review results from surveys of the 2002 harp seal pup production in the Greenland Sea.

Other elements of the terms of references must await formal requests, forwarded to WGHARP through the

ICES system.

9.3. Harbour porpoise

9.3.1 Update on progress

Haug 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. Analyses of the data are presently underway.

9.3.2 Future work

The Scientific Committee noted with interest that the small cetacean survey (following SCANS) as been scheduled for 2004 or 2005, and that the Faroe Islands and Norway have planned to participate.

9.4 and 9.5 Narwhal and Beluga

9.4.1 Update on progress

Narwhal

Narwhals occur in four concentrations areas in West Greenland: Disko Bay, Uummannaq, Melville Bay and Inglefield Bredning. Surveys in all these areas will have been attempted at the end of 2002, but for the Melville Bay and Uummannaq areas, the surveys may have to be repeated in 2003.

Capturing of whales for satellite tracking has been attempted in Disko Bay (1998-1999), Uummannaq (1995-1996) and Inglefield Bredning (2002). Live capturing of narwhals was not feasible for Uummannaq and Disko Bay. A new attempt for Inglefield Bredning will be launched in August 2003. .

Genetic studies have been conducted in all four areas and results have been published, but it is uncertain how useful the results will be for a future assessment.

In Canada the Department of Fisheries and Oceans is presently surveying a number of stocks of narwhals and there will, within the next couple of years, be more survey data available. Narwhals have been tracked from Eclipse Sound and Prince Regent Inlet but none of them went to West Greenland. Live capturing was attempted in 2002 in Admiralty Inlet and will be tried again in 2003. Aside from the major aggregations there are several smaller stocks of narwhals in Canada that may contribute marginally to the harvest in West Greenland. However at present there is no sure indication of a direct contribution from to the Greenlandic catch from Canadian stocks.

Beluga

Some new results from satellite tracking of belugas have become available since the Scientific Committee last performed an assessment in 2001, but the information does not provide a basis for altering the present advice. The next survey of belugas on the wintering ground in West Greenland will be conducted in March 2004. Results from this survey will – assuming successful completion – be available for revising the present advice in the autumn of 2004.

The Scientific Committee noted with satisfaction the progress in implementing a quota system for beluga and narwhal in Greenland, but further noted that recent harvest figures for Greenland indicate that little or no reduction in catch has taken place. The Committee has advised on 2 occasions (2000 and 2001) that the stock is substantially depleted and that present harvests are several times the sustainable yield, and that harvests must be substantially reduced if the stock is to recover. The Committee stressed that the apparent delay in reducing the catch to about 100 animals per year will result in further population decline and will further delay the recovery of this stock.

9.4.2 Future work

The Council has recommended that the Scientific Committee should concentrate its assessment efforts on the West Greenland narwhal in the near term, and that this assessment should be done jointly with the JCNB if possible. A future assessment of narwhals in West Greenland may require two consecutive meetings to answer specific questions and to set scenarios for runs of population models. While assessment work could potentially begin as early as Spring 2003, when the results of the Inglefield Bredning survey should be available, the Scientific Committee considered it advisable to wait until 2004, when surveys from other areas will have been completed and analysed. A subsequent meeting, probably in 2005, could deal with both narwhal and the new survey data for beluga which should be available at that time. Planning for future assessments will have to be done in conjunction with the Scientific Working Group of the JCNB, of which Witting is Chairman. He agreed to liaise between the two groups to find the best way to carry the assessment forward.

9.6 Fin whales

9.6.1 Update on progress

In 2002 the Council clarified its previous request for advice on fin whales, asking that the Scientific Committee continue with its assessments of fin whale stocks in the areas of interest to NAMMCO countries with existing and new information on abundance and stock delineation as it becomes available.

An estimate of the abundance of fin whales from the NASS-2001 survey has been completed (see Section 10.1). The Committee noted that abundance estimates from the Norwegian survey area of the NASS-1995 survey have not been published, and estimates from subsequent surveys in the Norwegian area have not yet been produced. The Committee recommended that these estimates be completed on a timely basis.

Bloch reported that she is continuing her efforts to review the catch series for fin whales in Faroese waters through archival research. Some discrepancies with the IWC catch database have been identified and corrected.

Efforts to tag fin whales with satellite-linked tags have continued in the Faroes, Greenland and Iceland. In the Faroes, 12 tag deployments have been made in the past 2 years, of which 2 have transmitted data. One of these animals moved into the waters west of Bay of Biscay, and had a tag life of 116 days, perhaps the longest recorded for this species. Bloch reported that further tagging would not be carried out until there was some indication that the success rate had improved. There have been some successful deployments in Greenland but none in Iceland.

Collection of tissue samples for genetic analysis has continued in the Faroes, Greenland, and Norway. In the Faroes and Norway, samples are collected through a biopsy program, while in Greenland samples are taken from the annual catch. Iceland has a large collection of tissue samples from historical catches, however virtually all of these are from western Iceland. The Committee noted that satellite tagging had indicated an apparent connection between fin whales in Faroes and in the waters near Spain and urged the addition of tissue samples from fin whales in these waters to ongoing studies on stock structure of North Atlantic fin whales. Samples may be available from the historical catch, or could be taken by biopsy.

9.6.2 Future work

The Scientific Committee noted that the success rate of deploying satellite tags on fin whales and other large whales was low and variable between research teams. There are several research groups working on large whale tagging in NAMMCO member countries, the USA, Japan and other countries, and the field is quite competitive. The Committee decided to establish an intersessional correspondence group to:

- identify progress in satellite tagging made in NAMMCO member countries and elsewhere;
- explore the technical aspects of satellite tagging, including deployment systems;
- briefly consider what tagging experiments have been done and the rates of success;

- recommend ways to further the development and success of this technique in NAMMCO member countries.

Víkingsson, Heide-Jørgensen, Mikkelsen and Nils Øien from Norway were appointed to serve on the committee, with Mikkelsen as chairman. The Committee will report their findings at next years meeting of the Scientific Committee.

The Scientific Committee considered that the new abundance data for the Faroese and Icelandic areas could allow the assessments for these areas to be updated in the coming year. An assessment of fin whales in the Norwegian area could be attempted if abundance estimates for the area are completed. One idea might be to co-schedule a fin whale assessment meeting with a minke whale assessment meeting, as many of the same people would be involved. Consideration should be given to contracting an update of the genetic analysis including new samples from the Faroes.

9.7 Minke whales

9.7.1 Update on progress

In 2002 the Council recommended that the Scientific Committee should complete an assessment of Central Atlantic minke whales once new abundance estimates from NASS-2001 become available.

Estimation of abundance from the 2001 aerial survey and a reanalysis of the 1987 aerial survey data are presently being conducted under contract to the Research Unit for Wildlife Population Assessment (RUWPA) at the University of St Andrews. Gunnlaugsson reported that analysis of the ship survey data is ongoing. Analysis of the 1996-2001 series of Norwegian sightings surveys, which includes part of the Central Atlantic stock, has been completed and reported to the IWC. Witting reported that an aerial digital photographic survey of minke whales and other species was ongoing in West Greenlandic waters, and would be repeated in 2003.

Víkingsson reported that satellite tags had been deployed on 2 minke whales this year, and one was still transmitting.

Walløe reported that genetic analyses of the large number of samples from the Norwegian catch were ongoing. However more samples from surrounding areas, including the Faroes and Iceland, are required to refine the analysis. The Scientific Committee recommended that tissue samples be collected from these areas by biopsy or other means.

9.7.2 Future work

The Scientific Committee considered that a new assessment of the Central Atlantic stock could be conducted after the Working Group on Abundance Estimates has considered the new estimates from the Icelandic aerial survey and the Icelandic and Faroese ship surveys from NASS-2001.

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

9.8.1 Update on progress

An abundance estimate for primarily white-beaked dolphins from the NASS-2001 Icelandic aerial survey has been produced (see 10.1), and estimates from previous aerial surveys are in progress. Estimates from the ship surveys have not been developed. Witting reported that the digital photographic aerial survey presently being conducted in West Greenland should produce data suitable for abundance estimation for dolphins.

Sampling programs from Icelandic bycatch of whitebeaked and the Faroese drive hunt whitesided and bottlenose dolphins have been conducted, and reports on life history and general ecology should be produced in the coming year. Norway will be initiating a sampling program involving the collection of approximately 60 whitebeaked dolphins for life history, genetic and feeding analyses. In addition biopsy samples are collected during sightings surveys.

9.8.2 Future work

At this point the Scientific Committee considered that there was still insufficient information on abundance, stock relationships, life history and feeding ecology to go forward with the requested assessments for these species. This may become feasible once further abundance estimates from the Icelandic and Faroese areas are produced, and the ecological studies in the Faroes, Iceland and Norway are completed. The Scientific Committee recommended that these studies be completed in a timely manner

9.9 Grey seals

9.9.1 Update on progress

Víkingsson reported that a survey of grey seals around Iceland would be conducted in fall 2002. Haug informed the Committee that abundance surveys of grey seals are conducted in Norwegian waters by ship, and that quotas are set using minimum estimates of abundance. He noted the need for more stock delineation work on this species.

9.9.2 Future work

In 2002 the Council requested that, given the apparent stock decline in Iceland, an apparent increase in Southwest Norway and in the United Kingdom, and the fact that this species interacts with fisheries in three NAMMCO member countries, the Scientific Committee provide a new assessment of grey seal stocks throughout the North Atlantic. Dr. Kjell Nilssen has accepted the position of chairman of the new Grey Seal Working Group. The general terms of reference of this Working Group will be:

- to assess the status of greys seals around Iceland, the UK, the Faroes, Norway, the Russian Federation, the Baltic, Canada and other areas;
- survey methods;
- stock delineation (genetics, temporal and geographical distribution);
- recommendations.

The Scientific Committee recommended that relevant international experts be invited to participate in the Working Group. In addition, working papers on stock status and other topics should be requested well in advance of the meeting. It was decided that the meeting should be held in early April in Iceland.

9.10.1 Harbour Seals

9.10.1 Update on progress

Haug informed the committee on the progress of the distemper outbreak in European harbour seals in 2002. Over 11,000 harbour seals have been reported killed by the outbreak so far, and if it follows the pattern of the 1988 outbreak, a large proportion of the population will be lost. The outbreak has affected seals in southern Norway but not so far in Iceland or Greenland.

9.11 Humpback whales

9.11.1 Update on progress

New abundance estimates from the NASS-2001 aerial and ship surveys are presently under development (see 10.1), and there is evidence from the Icelandic aerial surveys that the stock is increasing at a rapid rate in that area. There has also been an increase in both incidental and survey sightings around the Faroes. The aerial digital photographic survey being conducted in West Greenland should provide an estimate of abundance in that area.

Víkingsson reported that efforts to obtain photographs and biopsy samples from eastern Icelandic waters were continuing, as had been recommended last year. This year the first photographic match was made between one humpback from Icelandic waters and the Cape Verde breeding area. In Greenland, 4 satellite tags have been successfully deployed on humpback whales this year.

9.11.2 Future work

In 2002 the Council recommended that the Scientific Committee complete abundance estimates for this species as a high priority, and should also consider the results of the "Years of the North Atlantic Humpback" (YoNAH) project as it pertains to member countries in providing advice for this species.

The Scientific Committee noted that abundance estimates are being completed for this species as a high priority. Information from the YoNAH project, pertaining to stock delineation, migration, biological parameters, and abundance both North Atlantic-wide and in feeding areas has been published (Smith *et al.* 1999, Larsen and Berubé 2000, Larsen and Hammond 2000, EC YoNAH 2001, Palsbøll *et al.* 2001, Stevick *et al.* 2001). The Scientific Committee has noted previously (2001) that abundance estimates from the NASS-95 survey appear to conflict with the results of the YoNAH project, and comparison with the estimates from NASS-2001 should be of great interest.

10. North Atlantic Sightings Surveys

10.1 NASS-2001

10.1.1 Report of the Working Group on Abundance Estimates

The NASS-2001 survey was conducted in June - July 2001. The main purpose of the meeting was to review survey reports and abundance estimates from the survey, particularly for the target species minke and fin whales. Many of these estimates were only partially complete, so the Working Group was to recommend additional analyses to be conducted. A secondary objective was to evaluate the survey design and procedures used, and make recommendations for future surveys. Finally, the Working Group was asked to plan and schedule the publication of the results from NASS-2001, and those from previous surveys that had not already been published.

Minke whales

No abundance estimate was available for minke whales from the Faroese and Icelandic ship surveys. However the coverage and distribution of sightings in the Icelandic survey area may necessitate some non-standard analyses. Because of weather and ice related revisions to the survey plan in the northern and northwestern blocks, the coverage probabilities were substantially higher in some parts of strata than in others. Sightings of minke whales were highly clustered close to the northern and western edges of the western and northwestern blocks, presumably in association with the pack ice edge. This corresponds to an area of high coverage probability. The Scientific Committee recommended that a spatial analysis be considered for these data. However, given that the ship survey will likely contribute relatively little to the total estimate for the Central stock, the simpler alternative of post-stratification may be adequate to reduce the potential bias. Gunnlaugsson and Pike reported that both a traditional line transect analysis and an analysis using the methodology developed by Norway (Schweder *et al.* 1997) were being carried out on these data.

Stratified cue counting methods were used to calculate a preliminary estimate from the Icelandic aerial survey. The best estimate of minke whale abundance in the survey area was derived using only the data of the best observer and a cueing rate of 53 cues per hour (no variance estimate), 40,115 whales (95% CI 24,660 to 65,257) for the entire area. Known biases for this estimate include minke whale cues missed by observers (negative bias) and error in estimating radial distance (positive bias). An analysis that corrects for these biases is presently being conducted under contract with the RUWPA group at the University of St Andrews.

An analysis of trends in distribution and abundance of minke whales from aerial surveys conducted in the coastal waters of Iceland in 1986, 1987, 1995 and 2001 was considered. Line transect density was used as an index of relative abundance, and all datasets were treated in an identical manner so that any trend signal would not be masked by analytical differences. The distribution of minke whales was very stable from year to year, with highest densities in the SW, N and SE waters of Iceland. Relative abundance showed a significant increase in the area to the N of Iceland, and moderate but non-significant increases in the high-

density area in SW Iceland (Faxaflói), NW Iceland and in the survey area as a whole, over the period. The Scientific Committee concluded that the abundance of minke whales around Iceland has been stable or shown a moderate increase over the period. The apparent increase in relative abundance in the area to the N of Iceland is consistent with population growth after cessation of catching, however other factors, such as immigration from other areas, may also be involved. There are also indications of better feeding conditions off northern Iceland in 2001 than in previous surveys.

An analysis of data from the Icelandic and Faroese ship surveys is presently in progress.

Fin whales

The distribution of sightings of fin whales was more even than in earlier surveys, particularly in the blocks west of Iceland, where the distribution in previous surveys was more concentrated around the continental slopes. Double platform data collected indicated that the proportion of whales seen by the primary observers close to the trackline was close to 1 for this species, and that a correction for whales missed would not increase the estimate substantially while increasing the variance. The estimate for the total area of 25,352 is higher and has a lower CV than estimates from equivalent areas from past NASS surveys (Table 1). While some of this increase may be related to increases in survey efficiency, this factor alone likely cannot explain the observed increase since 1987. Stock increase, immigration from other areas, and/or variation in distribution between years may also be involved.

The Scientific Committee concluded that this estimate is likely to be only slightly negatively biased by perception and availability biases, and accepted that correcting for perception bias was not likely to be worthwhile. The four NASS ship surveys carried out since 1987 provide an excellent time series of abundance for this species. It was therefore recommended that a more complete analysis of changes in abundance over all the NASS surveys be conducted. This may require some re-analysis of past survey data as the coverage has changed between surveys.

Pike reported that he had begun "fine tuning" the estimate by using separate perpendicular distance functions for each of the 4 vessels involved in the survey. This will result in some slight changes to the individual block estimates, but virtually no change to the overall estimate. These results will be presented to the Working Group on Abundance Estimates at their next meeting.

Table 1. Abundance of fin whales from the NASS-2001 ship survey. *n*- number of sightings; *L*- effort; *N*- abundance estimate.

Block	Area (nm)	*n*	*L* (nm)	*N*	CV (%)	95% CI	
Icel.SW	190,577	31	1,169	2,723	27.87	1,480	- 5,009
Icel.W	154,692	271	2,424	10,800	15.20	7,862	- 14,836
Icel.NW	28,154	144	616	5,513	38.81	2,274	- 13,370
Icel.N	31,781	38	556	1,522	53.13	449	- 5,155
JanMayen	145,847	47	1,791	2,719	38.13	1,196	- 6,180
Faroe Isl.	117,500	62	2,457	2,074	27.39	1,139	- 3,777
Combined	668,551	593	9,013	25,352	12.71	19,576	- 32,831

Humpback whales

A preliminary line transect estimate for humpback whales from the 2001 Icelandic aerial survey has been completed. Sightings of humpback whales were highly concentrated off northeastern Iceland and to a lesser extent off southwestern and northern Iceland. A relatively high proportion of sightings close to the trackline by the secondary observers were duplicated by the primary observers, indicating that perception bias is low

but not absent for this species. The total number of humpback whales in the search area was estimated to be 3,057 (95% CI 1,727 to 5,410), with NE Iceland accounting for over half of this number. However this estimate has a negative bias because of perception bias and, probably more importantly, animals missed because they were diving when the plane passed.

Sightings from the NASS-2001 ship survey were also highly clustered around NE and W Iceland within the aerial survey block, but substantial numbers were also seen in areas farther offshore. More sightings were made in the Faroese block than in previous surveys. No estimate has been derived from these sightings as yet.

The contagious distribution of humpback whales seen in both the aerial and ship surveys may make spatial modelling a suitable analytical approach. It is likely that a spatial model would provide a more precise estimate and might enable some ecological interpretation of the observed distribution. A spatial analysis of the 2001 and 1995 aerial and ship survey data is now being conducted under contract to RUWPA at the University of St Andrews.

An analysis of the trend in encounter rate over the course of the 4 Icelandic aerial surveys carried out since 1986 showed an increase of 11.4% (SE 2.1%) per year over the period in the survey area. Encounter rates for other species did not change much over the period, so it seems unlikely that the increase for humpback whales can be attributed to changes in survey efficiency. This rate of increase is in accordance with that of 11.6% over the period 1970 to 1988 in recorded sightings humpback whales by whalers operating west of Iceland reported by Sigurjónsson and Gunnlaugsson (1990). Humpback whale sightings have also increased over the course of the NASS ship surveys conducted since 1987.

There has been almost no catch of humpback whales around Iceland since the first stage of Icelandic whaling came to an end in 1915 (Sigurjónsson and Gunnlaugsson 1990). Therefore, stock recovery is one plausible explanation for the trend, however the observed rate is on the edge of biological plausibility. Immigration from other areas may also be playing a role. The Yonah study (Palsbøll *et al*. 2001) has shown that there are at least 2 breeding populations of humpbacks in the North Atlantic, and that the whales around Iceland and Norway are a mixture of the 2 groups. It is possible that the stocks are growing at different rates, accounting for the apparent recent high growth rate around Eastern Iceland.

There has been very little sampling of humpback whales from E Iceland. Víkingsson noted that genetic and photographic sampling was planned for summer 2002, and would be continued if successful.

Lagenorhynchus dolphins

There were large numbers of dolphin sightings in the Faroese and Icelandic ship surveys, and in the Icelandic aerial survey. A preliminary abundance estimate for the Icelandic aerial survey has been completed. Species identification was uncertain but 96% of the sightings were identified as white-beaked dolphins, with the rest being of unknown species identity. The high proportion of white-beaked dolphins is consistent earlier surveys and other information from the area. The distribution of dolphins was consistent with earlier surveys, with animals being concentrated in N central, SW and SE Iceland, however dolphins were found almost everywhere in the survey area. Group size estimation was somewhat uncertain but there was no apparent bias in group size estimation with perpendicular distance. The total number of dolphins in the search area was estimated to be 20,444 (95% CI 12,714 to 32,874). This estimate is biased downwards both by perception and availability biases. There are duplicate data that might be used to correct for perception bias, but this has not been done yet. The Scientific Committee recommended that further analyses that incorporate the duplicate data be completed. It was also recommended that the other aerial surveys be analysed in a similar manner to look for temporal trends.

Virtually all sightings in the Faroese ship survey block were confirmed as white-sided dolphins. Some of these sightings were in an area in which white beaked were also seen on the aerial survey. This should be investigated further. Most sightings from the Icelandic vessels were of white-beaked dolphins, but many sightings were not identified to species and it was considered that species identification was uncertain even for those that were identified. Tracking of dolphin groups by the secondary observers was not very successful in either the Faroese or Icelandic surveys, so there is insufficient information to correct for availability bias or responsive movement.

The Working Group reiterated its conclusions from 2000, that while an analysis of the shipboard dolphin data from this and earlier surveys is feasible, the problems of uncertain species identification, uncertain group size estimation, and possible responsive movement of these species would present significant problems for abundance estimation. As a first step, the Icelandic members agreed to inspect the data for these species to determine if further analyses are likely to be useful. If so, an analysis that assigned species identification probability using relevant explanatory variables should be considered.

Pilot whales
A total of 87 sightings of 1,185 pilot whales was made by the Icelandic and Faroese vessels, more than in 1995. The Scientific Committee considered that, given the relatively high number of pilot whale sightings in the 2001 survey, and abundance estimation was worthwhile and should be conducted. Pike agreed to carry out the analysis. It was also noted that a recent successful application of satellite tags in the Faroe Islands will provide data with which to correct for availability bias for this species.

Sperm whales
A calculation of sperm whale abundance from the 2001 Icelandic and Faroese shipboard surveys was considered. For the first time data was collected in such a way that a cue count, using terminal dives as a cue, was feasible. The vessel to stopped or slowed down if it was heading to within 0.5 nm of a sperm whale to avoid triggering responsive cues, and the position of the cue relative to where the vessel would have been had it continued was used in the analysis. In addition to the cue count, which included only those animals that displayed a cue, a line transect estimate that included those animals that were visible on the surface as the vessel passed abeam was calculated. It was assumed that sperm whales cued twice per hour, and line transect estimate was corrected by assuming that sperm whales spent 20% of the time visible at the surface. For the Icelandic area, the weighted average of the two estimates was 9,477 (CV 0.406). A cue count estimate was not possible for the Faroese area because the positions of terminal dives were not recorded consistently. The ratio between the combined estimate for the Icelandic area, and a line transect estimate that included all sightings (1.41), was used to correct the Faroese line transect estimate to 1,708 whales. The combined estimate for the entire area was 11,185 (CV 0.34). Data from past Icelandic harvests has shown that only male sperm whales are found in these waters.

In discussion the Scientific Committee agreed that the methodology used was theoretically and practically valid. The cue rate and proportion of time spent on the surface used to calculate the estimate are of course crucial. While no data has been collected from this area, data collected from other areas could be applied to provide a better estimate of these parameters. Radio tagging studies in North Atlantic waters will however be required to provide more reliable estimates.

Bottlenose whales
More bottlenose whales were sighted in both the Icelandic and Faroese surveys than in previous surveys. As NAMMCO has used a line transect estimate from previous NASS surveys in an assessment of this species, it was considered worthwhile to proceed with a line transect estimate for this species, while recognising that it will have a substantial negative bias due to availability bias with this deep-diving species. In this regard the availability of dive data from Canadian waters was noted. Pike agreed to carry out the analytical work.

Killer whales
There were 36 sightings of killer whales in the Icelandic shipboard survey, and 8 in the Faroese block. The Scientific Committee considered that an abundance estimate derived from these sightings was unlikely to be of use. However the distribution should be compared with that seen in earlier surveys.

Blue whales
The Icelandic ship survey produced 29 sightings of blue whales, while 9 sightings were made in the aerial survey. While this is likely too few to derive a meaningful abundance estimate, it might be useful to compare encounter rate between surveys to determine if there is any evidence of a trend in relative abundance. However it was noted that such a trend might be confounded by between-survey differences in the effort dedicated to differentiating blue and fin whales. More effort was made to discriminate the species in 2001 than in earlier surveys.

Evaluation of survey methodologies
The Working Group provided a detailed evaluation of the methodologies used in the ship and aerial surveys, and a list of recommendations for improvements. The Scientific Committee considered that the Report and the contributory working papers should serve as an excellent guide for the planning and conduct of future NASS surveys.

Ship surveys
A major problem with the setup on the Faroese vessel was that the tracker platform was lower than the primary platform. Problems were also experienced with vibration on the tracker platform, making it difficult and uncomfortable to use the binoculars. The primary observers were instructed to search for both the primary species, minke and fin whales, which required them to search at greater distances from the platform than they would have if only minke whales had been targeted. The Buckland-Turnock (BT) design requires the tracker to search substantially further than the primary observers. This requirement was compromised on both the Faroese and Icelandic vessels. Few trackings of minke whales were made on the Icelandic vessels, probably because weather conditions prevented the trackers from seeing small whales at large distances, and possibly also because the observers tended to focus their search on the target fin whale. The application of the BT method was therefore not successful in terms of correcting for responsive movement and availability bias, although the duplicate data will still be useful in correcting for perception bias, and was felt to be useful in keeping observers alert.

The Scientific Committee considered that the application of the BT methodology was problematic in a combined survey for large and small whales, which did not restrict primary search effort to be substantially closer to the vessel than tracker search effort. On these surveys, the BT method was compromised, and few trackings were made. If the BT method was applied as intended, with the primary platform searching close to the platform and the tracker platform searching farther away, it is still likely that sufficient sightings of large whales would have been made.

Another possibility would be to use symmetric platforms, with all observers tracking whales and recording cues and tracking whales, as in the Norwegian minke whale surveys. Duplicate matching would be done after the survey rather than in the field. Initial sightings could be classified by distance to derive corrections for responsive movement and availability bias using the method of Palka and Hammond (2001). Such a methodology would benefit from automated timing of cues, as is done in the Norwegian surveys. The effort put into tracking might also reduce the total number of sightings, but this might not be problematic as the effort applied is increased by fully utilising the data from both platforms.

It was emphasised that the double platform methodology in general was successful and will prove useful particularly in refining the estimates for minke whales and other smaller species. Further effort should be devoted to the automation of data recording and entry so that observers can be better monitored by the cruise

leader in the field. Finally, special attention must be paid to the design of platforms to reduce vibration, improve visibility and increase observer comfort.

The Scientific Committee noted that sharing of survey platforms with the redfish survey had apparently been successful. International redfish surveys will be carried out over similar areas on a 3-year rotation, and cover a larger area to the south and west of the NASS-2001 survey area. The Scientific Committee recommended to further investigate the possibility of using future redfish surveys to conduct or extend cetacean surveys by sharing platforms with all participating vessels in the redfish survey.

Aerial surveys

A fundamental consideration was whether cue counting from an airplane was the best approach to estimate minke whale abundance in Icelandic nearshore waters. The methodology is very demanding of observers, sensitive to distance estimation error and differences in sighting patterns between observers, although these factors can be accounted for in the analysis. There have been problems with the conduct (1995, 2001) and analysis of data (all years) from the surveys that make comparisons of absolute abundance between surveys difficult.

The Scientific Committee, however, considered that that cue counting from an airplane should be an effective methodology for minke whales. Correcting line transect estimates for availability bias is more difficult than for doing so for cue counting. The Scientific Committee concluded that with the practical recommendations for improvements in equipment and procedures contained in the Working Group Report, cue counting was still the best available methodology for minke whale surveys in this area.

The Scientific Committee agreed that the possibility of using an aerial digital photographic survey should be considered, once this technique has been fully tested for large whales in Greenland.

10.1.2 Future work

The Scientific Committee agreed that completion of the following analyses should be of high priority for the Working Group:

i. Aerial survey estimate of minke whales around Iceland from 2001 and 1987, accounting for bias due to measurement error and whales missed by observers. This work is presently being pursued under contract to RUWPA.
ii. Spatial analysis of humpback whale distribution and abundance, from 2001 and 1995 ship and aerial surveys. This work is presently being pursued under contract to RUWPA.
iii. Abundance estimate of minke whales from Faroese and Icelandic ship surveys, 2001. This is in progress;
iv. Abundance estimates for dolphins from the 2001 and earlier surveys;
v. Abundance estimates for pilot whales and northern bottlenose whales from the 2001 survey.

It was anticipated that all or most of this work could be completed in time for a meeting of the Working Group early in 2003.

10.2 Status for analyses and publications from previous NASS surveys

Although the idea of publishing a volume on the North Atlantic Sightings Surveys (NASS) was dropped in 2000 by the Scientific Committee, it was revived in 2001 following the NASS-2001 survey. The Scientific Committee then directed the Working Group on Abundance Estimates to devise a plan for the publication of results from NASS-2001 and earlier surveys.

The Working Group agreed that a special volume on the NASS surveys in general would be of great interest to many researchers. Four NASS surveys have been conducted, over a long enough time frame that temporal trends in distribution and abundance may be detectable. The volume therefore should not merely report abundance estimates from the later surveys, but should synthesise results from all the NASS surveys to

elucidate temporal and spatial patterns. It was considered that the volume could best be organised by species, with contributors using information from all the NASS surveys regardless of national affiliation. Nils Øien agreed to act as editor for the volume.

Subsequent to the meeting, Pike and Øien drafted a list of prospective papers that could be developed for such a volume and this was presented to the Scientific Committee. Given that none of these papers have yet been written, and some will require further data analysis, this volume could not be completed before sometime in 2004. The Scientific Committee supported the idea of proceeding with this new volume of NAMMCO Scientific Publications, which will be the sixth in the series. Øien and Pike have agreed to edit the volume.

11. NAMMCO SCIENCE FUND

At the 9th meeting of the NAMMCO Council in 1999, the Chairman of the Scientific Committee, Dr Mads Peter Heide-Jørgensen, proposed that the Scientific Committee be given the option of conducting its own research with funding provided by the Council. This would facilitate closer co-operation 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, multi-species interactions, or generally to address the priorities of both the Scientific Committee and the Council. Subsequently the Scientific Committee developed a full proposal for such a Science Fund, with 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. The proposal for the Science Fund, along with these examples of projects that could be conducted under the program, was presented to the Council at their 11th meeting in February 2002.

In discussing this matter, the Council noted that the establishment of such a fund would reduce the funding available to National Research Institutions, and would result in no net increase in funding for marine mammal research. The Council therefore decided not to support the establishment of a NAMMCO Science Fund. The Council did however acknowledge that a better way must be found to convey the priorities of NAMMCO to National Research Institutions.

The Scientific Committee expressed its profound disappointment that a Science Fund could not be established. As the intention of the Fund was to fund research that would facilitate and accelerate the response of the Scientific Committee to requests put to it by the Council, the Committee noted that its recommendations for research must be acted upon by national research institutes if the requests of the Council are to be fulfilled in a timely manner.

12. DATA AND ADMINISTRATION

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 and explanation or need to be updated due to subsequent decisions of the Council. A new draft of the *Rules* was prepared by the Scientific Secretary and approved by the Scientific Committee in 2001. The proposed draft was then submitted to the Council for approval.

Two minor revisions of the *Rules* were required by the Council. Firstly, the Council has found the Executive Summary of the Report of the Scientific Committee useful and wishes to see this practice continued. Secondly, some member countries need a period of at least 3 months to review and consider the contents of the Report of the Scientific Committee before they meet in Council. Therefore the *Rules* have been revised so that meetings of the Scientific Committee must be held at least 14 weeks before meetings of the Council.

The final *Rules of Procedure for the NAMMCO Scientific Committee*, with the associated Annex 1 *Guidelines for the Release of Documents by the Scientific Committee*, were approved by the Committee and are included as Appendix 4.

The Scientific Committee expressed some concern that the long time gap between meetings of the Scientific Committee and the Council, during which the Report of the Scientific Committee cannot be distributed, means that some of the recommendations of the Committee cannot be acted on in a timely manner. It also prevents Committee members from bringing the findings of the Committee into other fora where they may be of great interest, if meetings occur in this period. The Committee urged the Council to find a way to approve the Report in a timely manner, perhaps via an intersessional meeting.

13. PUBLICATIONS

13.1 NAMMCO Scientific Publications

Three volumes of NAMMCO Scientific Publications have now been published: Vol. 1 *Ringed seals in the North Atlantic*, Vol 2 *Minke whales, harp and hooded seals: Major predators in the North Atlantic ecosystem*, and Vol. 3 *Sealworms in the North Atlantic: Ecology and population dynamics*. The latter was published late in 2001 and has been distributed to libraries, research institutions and to journals for review.

The following volumes are presently in progress:

Belugas in the North Atlantic and the Russian Arctic. ed. Heide-Jørgensen, M.P. and Wiig, Ø. *NAMMCO Sci. Publ.* 4.
This volume is in the final stages of publication and should be out in October.

Harbour porpoises in the North Atlantic (no title chosen yet). ed. Haug, T., Desportes, G., Víkingsson, G. and Witting, L. *NAMMCO Sci. Publ.* 5.
At the time of this meeting all papers for this volume have been received for final technical editing and publication. The volume will contain 4 keynote papers and 12 papers in the 4 theme areas. It is anticipated that the volume will be out early in 2003.

In addition the Scientific Committee has decided to proceed with a volume on the North Atlantic Sightings Surveys (See section 10.2).

14. BUDGET

The Scientific Secretary presented a draft budget for the Scientific Committee for 2002. 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 over half of the budget allocation is being used to fund contract analyses of NASS data.

At least 4 working groups are expected to be active in 2003 (see 15.2), and some contract work will be necessary to support these working groups. These costs might exceed the usual budget allocation of the Scientific Committee.

15. FUTURE WORK PLANS

15.1 Scientific Committee

It was decided that Greenland shall host the next meeting of the Scientific Committee in November 2003, at a location yet to be determined.

15.2 Working groups

Working Group on Grey Seals

The Working Group will meet early in April 2003 in Iceland. Dr Kjell T. Nilssen is chairman.

Working Group on Abundance Estimates

The Working Group will meet early in 2003 at a time and location to be determined. Dr Nils Øien will continue as chairman.

Working Group on North Atlantic Fin Whales

The Working Group will meet in November 2003, immediately before the meeting of the Scientific Committee and in association with the new Working Group on North Atlantic Minke Whales. Víkingsson is chairman.

Working Group on North Atlantic Minke Whales

The Working Group will meet in November 2003 in association with the Working Group on North Atlantic Fin Whales. A chairman will be appointed intersessionally.

Working Group on Marine Mammal - Fisheries Interactions

Walløe will provide the Committee with a report on progress in modelling efforts, at which time the Committee will decide if another meeting is warranted. It is anticipated that the next meeting will likely be held in 2004. Walløe will continue as chairman.

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

The Working Group will likely meet in 2004 to conduct assessment work on narwhals. If possible the meeting should be held jointly with the Scientific Working Group of the JCNB.

Satellite Tagging Correspondence Group

This group will meet by correspondence under the chairmanship of Mikkelsen, and report back to the Scientific Committee at their meeting in 2003.

Advice Requests Correspondence Group (see 15.3.1)

This group will meet by correspondence and report back to the Scientific Committee by correspondence by late January 2003. Their approved report will be used to provide advice to the Council on the information required in requests for advice when the Council meets in March 2003.

15.3 Other matters

15.3.1 Provision of advice on sustainable catch to Council

In the past the Scientific Committee has been asked to provide assessments and advice on sustainable catch for several species including killer whales, bottlenose whales, beluga, harp and hooded seals, ringed seals and walrus. Recently the Council of NAMMCO has given the Scientific Committee additional requests for advice about sustainable catch levels for Central Atlantic minke whales, fin whales, narwhal and grey seals. It would appear then that the provision of advice on sustainable catch will be a major near-term activity of the Scientific Committee, and that this activity can be expected to increase in the future. Pike presented a discussion paper (SC/10/15) on ways the Scientific Committee might improve and enhance the provision of advice to the Council.

A review of requests for advice from the Council shows that they have varied quite widely. In cases where a "general" stock assessment was requested, i.e. for Central Atlantic minke whales, bottlenose whales, and pilot whales, the resulting advice given by the Scientific Committee was also quite general in nature with regard to catch options. Generally the main conclusion is that present (or past) catches are/are not sustainable. No advice is offered on the possible effects of other harvest options.

More specific requests, which explicitly mention potential catch levels, have been made for fin whales. The resulting advice is more satisfactory in that it provides stock forecasts for these catch levels. On the other hand, there has been no definition of an "acceptable" level of risk of stock decline, so this has been left to the judgement of the Scientific Committee. The request for West Greenland beluga specified catch options under "different management objectives", but did not say what these objectives might be. The Committee specified a paramount objective of halting the decline of this stock.

It is apparent that more specific and detailed requests for advice from the Council result in more useful advice from the Scientific Committee. Focussing on specific management goals for the stock, catch levels and acceptable levels of risk enables the development of models that take these factors explicitly into consideration. With very general requests (e.g. Central Atlantic minke whales), the Scientific Committee can offer advice on the probable effect of past catches, and of future catches of similar levels, but cannot advise on any appropriate level of catch because management objectives are not known. In contrast, when the Scientific Committee works with a specific management objective (e.g. West Greenland beluga), they can offer very specific advice that can be easily translated into management action.

It would appear that relatively few organizations involved in fishery management actually use a well-defined management procedure. Examples considered included the Revised Management Procedure, Potential Biological Removal and harp and hooded seal advice provided by ICES. The use of an explicit and documented management procedure or procedures would have some advantages for the Scientific Committee and NAMMCO as a whole. A management procedure takes most of the "judgement" out of management decisions, making them more defensible in terms of conservation. Management procedures can make it more straightforward for the Scientific Committee to respond to requests for advice from the Council, as existing models and pre-defined catch rules would be used. The Scientific Committee would no longer have to guess at the management goals of the Council, as these would be implicit in the procedure used.

A single management procedure can fit a rather narrow range of possibilities in terms of management goals and acceptable levels of risk to the stock. As such they are most applicable to a single type of fishery where these factors are pre-defined. For example the RMP is specifically developed for commercial whaling on baleen whales, and a separate procedure is being developed for aboriginal subsistence whaling. The PBR catch rule is designed mainly for non-fishery, bycatch removals, where minimisation of risk to the stock is paramount. On the other hand, the balance between catch and risk to the stock can be adjustable, as for example with the tuning parameter of the RMP. Therefore management procedures like the RMP may be generalisable to management situations with somewhat different stock objectives than those for which it was originally designed

All management procedures developed to date are essentially single stock models that do not take into account other ecosystem relationships. In one sense this is not really relevant for procedures like the RMP, which use only information on stock trajectory and catch. It can be argued that the factors affecting stock trajectory, for example prey availability, are not relevant to the immediate goal of specifying catch levels that will maintain the stock above a specified level of depletion. In addition, such factors are generally not known and may not be susceptible to management intervention even if they are known. Nonetheless, the target level set for a stock may have implications for other fisheries (e.g. Schweder *et al.* 1998, 2000a), so multispecies and ecosystem considerations may play a larger role in future management procedures.

The development of any management procedure requires rigorously defined management objectives, including acceptable levels of depletion, levels of acceptable risk and time periods over which these factors are evaluated. NAMMCO has not yet defined these objectives for any species or fishery, and it is not clear whether they will do so. Therefore, the development and use of a management procedure by NAMMCO

would be premature. Nevertheless, there may be specific cases where existing procedures, like the RMP or PBR, may be applicable or readily adaptable to a request for advice.

Another option for the Scientific Committee, applicable to all stocks and fisheries, would be to present advice that explicitly presents the risk of stock depletion at various levels of catch. An example of this is the advice developed by the Scientific Committee for West Greenland beluga. Such a presentation allows the management authority to choose the catch option that best suit their management objectives, even if they have not stated them explicitly. However even such a presentation of options requires the Committee to make decisions about the level of acceptable depletion and period of time to be evaluated.

In discussion the Scientific Committee agreed that the explicit statement of management goals was one of the most important considerations in providing high quality scientific advice on sustainable catch. Requests for advice on catch levels should contain a minimum of information about management goals and timelines so that they can be responded to effectively. It was agreed that a Correspondence Group should be established to provide guidance to the Council in the most effective formulation of requests for advice. Witting agreed to chair the correspondence group. The group will report to the Scientific Committee by correspondence before the next meeting of Council so that their recommendations can be approved by the Committee. These recommendations will then be presented to the Council at their meeting in March 2003.

The Committee considered that one of the main problems with the use of explicit management procedures such as the RMP was the lack of flexibility in adapting to different management goals and different types of fisheries. While part of the intention in developing such procedures was to reduce the workload on the committee providing advice, experience with the RMP had shown that this was not necessarily the end result. The Committee was also concerned that once an explicit management procedure is adopted at the political level, it can be difficult to change some of the parameters and assumptions of the procedure even if they are demonstrated to be false.

The Scientific Committee favoured an approach where advice on catch levels is presented in a form that shows the probability of achieving desired stock trajectory under different catch options, with a full evaluation of the uncertainty of the predictions, if sufficient data are available to support such an assessment. The advice provided for West Greenland beluga is one example of this approach. In conducting assessments, it is also advantageous to use more than one assessment model if available, as this increases confidence in the results.

17. ELECTION OF OFFICERS

Gisli Víkingsson was elected as chairman for an additional year, and Lars Walløe was elected as vice chairman.

18. ANY OTHER BUSINESS

International Convention on Migratory Species

Walløe brought to the attention of the Committee that the International Convention on Migratory Species (CMS), the Bonn Convention, was considering the listing of a number of species of whales as being threatened with extinction or having an unfavourable conservation status. Once listed, member countries will be obligated to take management actions that may preclude harvest in some circumstances. The main reason for the listing action would appear to be that some of these species are also listed in the IUCN "Red List".

The Scientific Committee expressed concern about this matter and noted that many Red List classifications were themselves outdated and based on questionable information. It was considered that international

organisations have a responsibility to be critical and conduct credible research when taking action that may affect the resource use activities of their members.

The Scientific Committee will therefore advise the NAMMCO Council and the member governments to initiate a scientific review and revision of the "Red List", so that new and more accurate status can be assigned to each of the North Atlantic marine mammals species.

Age determination center

The Scientific Committee had received an unsolicited proposal from Dr Christina Lockyer for the setting up of an international age determination centre for mammals to answer the needs of various baseline research studies connected with life history and population parameters required for management and conservation. The proposed centre would provide ageing services as well as training and calibration of ageing with other laboratories.

The Scientific Committee considered that such a centre would be useful to laboratories and institutions in member countries, where ageing activity is too sporadic to maintain dedicated trained personnel. It would also be useful for training of ageing technicians and to facilitate inter-laboratory comparisons. While the Scientific Committee is not in a position to offer financial support for the establishment of such a centre, it was agreed that its establishment would be a positive step and should be supported.

19. ACCEPTANCE OF REPORT

The Report was accepted on September 19, 2002. The Scientific Committee expressed their thanks for the use of Hvalfjörður facility and noted that the beautiful surroundings had enhanced the atmosphere of the meeting.

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Appendix 1

TENTH MEETING OF THE SCIENTIFIC COMMITTEE

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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. Incorporation of the users knowledge in the deliberations of the Scientific Committee.
7. Update on Status of Marine Mammals in the North Atlantic
8. Role of marine mammals in the marine ecosystem
   - 8.1 WG on marine mammal - fisheries interactions
   - 8.2 Other matters
9. Marine mammal stocks -status and advice to the Council
   - 9.1. Harp seals
     - 9.1.1 Update on progress
     - 9.1.2 Future work
   - 9.2. Hooded seals
     - 9.2.1 Update on progress
     - 9.2.2 Future work
   - 9.3. Harbour porpoise
     - 9.3.1 Update on progress
     - 9.3.2 Future work
   - 9.4. Narwhal
     - 9.4.1 Update on progress
     - 9.4.2 Future work
   - 9.5 Beluga
     - 9.5.1 Update on progress
     - 9.5.2 Future work
   - 9.6 Fin whales
     - 9.6.1 Update on progress
     - 9.6.2 Future work
   - 9.7 Minke whales
     - 9.7.1 Update on progress
     - 9.7.2 Future work
   - 9.8 White-beaked, white-sided dolphins and bottlenose dolphins
     - 9.8.1 Update on progress
     - 9.8.2 Future work
   - 9.9 Grey seals
     - 9.8.1 Update on progress
     - 9.8.2 Future work
   - 9.10 Humpback whales
     - 9.10.1 Update on progress

Appendix 3

LIST OF DOCUMENTS

	Title
SC/10/1	List of Participants
SC/10/2	Provisional Annotated Agenda (Draft)
SC/10/3	List of Documents
SC/10/NPR-F	National Progress Report – Faroe Islands
SC/10/NPR-G	National Progress Report – Greenland
SC/10/NPR-I	National Progress Report – Iceland
SC/10/NPR-N	National Progress Report – Norway
SC/10/4	Observers Report: 54th Meeting of the IWC Scientific Committee, Shimonoseki, Japan
SC/10/5	NAMMCO Conference "User Knowledge and Scientific Knowledge in Management Decision Making"
SC/10/6	Status of Marine Mammals in the North Atlantic – Update
SC/10/7	Workshop Report: Modelling marine mammal - fishery interactions in the North Atlantic.
SC/10/8	Report of the NAMMCO Scientific Committee Working Group on Abundance Estimates.
SC/10/9	Status of the proposed NAMMCO Science Fund
SC/10/10	Revisions to the Rules of Procedure for the Nammco Scientific Committee
SC/10/11	Update on NAMMCO Scientific Publications
SC/10/12	NAMMCO Scientific Committee Budget 2002.
SC/10/14	Summary of requests by NAMMCO Council to the Scientific Committee, and responses by the Scientific Committee
SC/10/15	Provision of advice on sustainable catch to Council
SC/10/16	Haug, T. Nilssen, K.T., Corkeron, P. and Lindblom, L. Diets of harp and hooded seals in drift ice waters along the east coast of Greenland.

	Title
SC/10/17	Lockyer, C. Proposal for establishing an Age Determination Centre – start-up funding
SC/10/18	Report on the estimation of minke whale abundance around Iceland from the NASS 2001 and 1987 aerial surveys.
SC/10/19	Heide-Jørgensen, M.P. Prospects for future NAMMCO assessments of narwhals and belugas in Baffin Bay

Appendix 4

RULES OF PROCEDURE FOR THE NAMMCO SCIENTIFIC COMMITTEE

I. TERMS OF REFERENCE

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

II. MEMBERSHIP

1. Each Contracting Party shall nominate up to three scientists as members of the Scientific Committee. The appointment is permanent or until the Contracting Party nominates new member(s) to the Committee. Each member of the Committee shall have one vote when procedural or organisational matters are being dealt with.
2. The Scientific Committee shall elect by majority vote from amongst its members a Chairman and a Vice-Chairman. The Chairman and Vice-Chairman shall serve for two years, after which they may be re-elected. The terms of office of the Chairman and Vice-Chairman shall begin at the conclusion of the NAMMCO Council meeting for the year in which they are elected.
3. If for any reason the Chairman is unable to complete his term of office, the Committee shall elect a new Chairman at its next regular meeting. If needed, the Chairman of the Council may call for postal elections of the Chairman and Vice-Chairman of the Scientific Committee.
4. The General Secretary and the Scientific Secretary of the NAMMCO Secretariat shall be *ex officio* non-voting members of the Scientific Committee.
5. The Scientific Committee may, on an *ad hoc* basis and subject to the approval of the Council, nominate experts to participate in meetings of the Committee as *ex officio* non-voting members. Any such nomination of experts must reach the Secretary of NAMMCO no later than 30 days before the start of the meeting in question.

III. OBSERVERS

1. Canada and the Russian Federation shall be invited to send one (1) observer each to annual meetings of the Scientific Committee.
2. Other organizations may be invited to send observers to annual meetings of the Scientific Committee, subject to the approval of the Committee and the Council.
3. Participation of observers in the deliberations of the Scientific Committee will be at the discretion of the Chairman

IV. ORGANISATION

1. The Scientific Committee is responsible for collecting and compiling the necessary information for providing scientific advice. While avoiding duplication of work being carried out elsewhere, the Committee decides where and how this information is to be obtained. If the Committee considers it necessary to consult information not available in the published literature or in the possession of any of the Parties, any cooperation in this field with external authorities shall be undertaken by the Scientific Committee Chairman through the Secretary of NAMMCO.

2. The Scientific Committee may establish designated Working Groups on clearly defined subjects related to the work needed to be carried out for dissemination of the required scientific advice.
3. The Scientific Committee decides the terms of reference of the Working Groups, their provisional agenda, membership, Chairmen and dates of meetings, and makes proposals to the Council on invitation of external experts or observers.
4. The Working Groups report their findings in writing to the Scientific Committee according to their terms of reference.
5. The Scientific Committee shall report its findings in writing to the Council within two weeks after concluding its deliberations . The contents of the report shall be considered strictly confidential prior to that. The Report of the Scientific Committee shall include an Executive Summary. The Chairman seeks to have all views expressed on substantive matters during the deliberations in the Committee made clear in its report and the wording approved by the Committee before the end of its meeting or by correspondence if agreed by the Committee. Approval of the report requires consensus among the Committee members.

V. MEETINGS

1. The Scientific Committee shall meet at least annually, at least 14 weeks prior to the regular meetings of the Council, unless otherwise decided by the Committee or the Council. Intersessional meetings may be held when judged necessary by the majority of the Scientific Committee and/or the Council so decides.
2. A provisional agenda for all Scientific Committee meetings shall be developed by the Chairman and distributed to the members of the Committee no later than 30 days prior to the meeting in question. Comments or suggestions for revision of the provisional agenda shall reach the Chairman no less than 10 days prior to that meeting.
3. The Chairman shall, in consultation with other members of the Committee and the Secretariat of NAMMCO, seek to ensure that key documentation of relevance to the provisional agenda is available at the start of each meeting. This may involve compilation of published information and invitation to members, Parties, Working Group Chairmen or external experts to submit and present scientific papers at the meetings. Any scientist may submit scientific paper(s) for consideration by the Committee and Working Groups, as appropriate.
4. Each Party having information on the biology of marine mammals relevant for NAMMCO management objectives, including research and statistical material on catches of relevant species or stocks, shall briefly report on such information at the relevant meetings of the Scientific Committee or its Working Groups.
5. The Scientific Committee, in consultation with the Secretariat of NAMMCO, shall make proposals for contract studies to be conducted on specific agenda items to be dealt with at meetings of the Scientific Committee or its Working Groups.
6. The Secretariat of NAMMCO may, with the concurrence of the Committee, set technical guidelines for the preparation, format and presentation of all meeting documents, including type and format of data on catches that each Party reports with respect to any relevant catch operation.
7. Titles of meeting documents outlined in V.3.-5. above shall, if possible, reach the Secretariat of NAMMCO no less than 10 days in advance of the meeting in question and be distributed to the members of the Committee/Working Group prior to the meeting. All documents registered before the end of the first day of the meeting shall be considered Primary Documents for consideration at the meeting.
8. English shall be the official language of the Scientific Committee and all primary documents shall be written in English. The Chairman can give exemptions from this general rule after consultation with other Committee members and the Secretary of NAMMCO.

VI. DATA AVAILABILITY

1. The Report of the Scientific Committee and the reports of the Committee's Working Groups shall be made available by the Secretariat to anyone that so wishes, according to guidelines set by the Scientific Committee and after they have been dealt with by the Council. Such guidelines are subject to approval by the Council and are included as Annex 1. The Scientific Committee shall aim to have all key scientific papers relevant to its work published in a recognised international scientific journal.
2. Unpublished scientific papers submitted to the Scientific Committee or its Working Groups shall be available only to the Scientific Committee and the relevant Working Group(s). Such papers will not be further distributed or cited without the express permission of the primary author.
3. The Secretariat of NAMMCO may, with the concurrence of the Scientific Committee and the Council, require that statistical material and computing programs for use in evaluation of the status of stocks or for calculations of catch limits, such as detailed catch and abundance data, be submitted in advance to the Secretariat in an electronic data storage medium, for validation and preparation prior to the meeting. Submitted statistical material or other raw data shall only be released from the Secretariat subject to approval of the scientist or Party submitting the data.

VII. AMENDMENTS OF RULES

Proposals for amendment of these rules of procedure shall reach the Secretariat not less than 60 days prior to the Council meeting at which the matter is to be discussed. The Secretariat shall inform the Contracting Parties about these proposals not less than 30 days prior to that meeting.

ANNEX 1

GUIDELINES FOR THE RELEASE OF DOCUMENTS BY THE SCIENTIFIC COMMITTEE

1. Documents for meetings of the Scientific Committee and subsidiary Working Groups shall be made available to Committee or Working Group members and observers in advance of the meeting if possible, or on the first day of the meeting.
2. Reports of subsidiary Working Groups shall be given to the Scientific Committee as soon as they are completed and accepted by the Working Group.
3. The Report of the Scientific Committee will not be distributed outside of the Scientific Committee until it has been dealt with by the Council.
4. Subject to (3.), the Report of the Scientific Committee will be distributed by the Secretariat to international government organisations, observer and other governments, non-government organisations, researchers and other interested parties according to a distribution list maintained at the Secretariat.
5. Subject to (3.), the Report of the Scientific Committee will be given to any organisation or individual on request. The Secretariat reserves the right to charge for printing and distribution.
6. Subject to (3.), a summary of the Report of the Scientific Committee will be published on the NAMMCO internet site.
7. Subject to (3.), the full Report of the Scientific Committee will be published on the NAMMCO internet site.
8. The full Report of the Scientific Committee, including the reports of subsidiary Working Groups, will be published in the NAMMCO Annual Report.
9. Unpublished scientific papers submitted to the Scientific Committee or its Working Groups shall be available only to the Scientific Committee and the relevant Working Group(s). Such papers will not be further distributed or cited without the express permission of the primary author.

Annex 1

NAMMCO SCIENTIFIC COMMITTEE WORKING GROUP ON ABUNDANCE ESTIMATES

Kerteminde, 13-15 March, 2002

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 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. In response, the Scientific Committee convened a meeting of this Working Group in November 2000, for the dual purpose of continuing analyses from previous NASS surveys, and planning a NASS survey for 2001. The Working Group developed a survey plan which incorporated vessel surveys by the Faroe Islands, Iceland and Norway, and an aerial survey around coastal Iceland, as in previous NASS surveys. This plan was further developed and modified by correspondence among Working Group members and at an additional training/planning meeting held immediately before the survey. The NASS-2001 survey was conducted in June - July 2001.

The main purpose of the meeting was to review survey reports and abundance estimates from the survey, particularly for the target species minke and fin whales. Many of these estimates were only partially complete, so the Working Group was to recommend additional analyses to be conducted. A secondary objective was to evaluate the survey design and procedures used, and make recommendations for future surveys. Finally, the Working Group was asked to plan and schedule the publication of the results from NASS-2001, and those from previous surveys that had not already been published.

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. Document SC/10/AE/4, Abundance of minke whales from NASS-2001 ship surveys, had not been completed in time for the meeting. An additional document describing the Faroese ship survey was accepted as SC/10/AE/15. In addition, working papers from previous meetings of the Working Group, and other published documents, were also available as needed.

5. SURVEY REPORTS

Working papers describing the general methodology and results from the 2001 ship and aerial surveys were briefly reviewed by the Working Group. Target species of the surveys were minke and fin whales for the Faroes and Iceland, and minke whales for Norway. For the first time the Faroese and Icelandic vessels used identical methodology, a Buckland-Turnock (BT) mode using 2 independent observer platforms. This

involves one platform (the "tracking" platform), searching further ahead to set up "trials" from which the detection function of the other platform (the "primary" platform) is estimated. It requires the primary platform to operate independently of the tracker platform, but not vice-versa. 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.

After the survey had begun, permission to enter UK territorial waters was withdrawn for the Norwegian vessel and refused for the Faroese vessel. This necessitated a last-minute re-allocation of survey effort by the Norwegian vessel from the North Sea to the Norwegian Sea, and the abandonment of part of the planned Faroese survey block. The Working Group noted that because of this important areas were not surveyed, reducing the overall value of the survey results.

The final survey plan is shown in Fig. 1, and realised effort and sightings are shown in Fig. 2 - 12.

Faroese ship survey
The refusal of admittance to UK waters significantly reduced the size of the Faroese block. Consequently there was higher coverage in this reduced area. The primary north-south tracks were completed, and part of the secondary east-west tracks were completed as well. Weather was relatively good throughout the survey and most lines were completed in Beaufort sea state of 4 or less. A total of about 2,500 nautical miles was covered on effort, and 459 groups of cetaceans comprising twelve species and 1,798 individuals were sighted. The most common species were by rank pilot whales, sperm whales, bottlenose whales, white-sided dolphins, harbour porpoises, minke whales and fin whales.

Icelandic ship survey
Subsequent to the November 2000 Working Group meeting, it was decided in Iceland to share survey effort on an international redfish survey being conducted by Icelandic survey vessels participating in the survey. This necessitated a change in the survey area, block structure and effort allocation. The northern and eastern parts of the Icelandic area were still surveyed by a dedicated survey vessel.

Planned transects had to be adjusted because of prevailing weather and ice conditions, particularly in the northern and northwestern areas covered by the dedicated vessel. The primary target species of the survey were minke and fin whales but an emphasis was made to identify as many sightings to species as possible in particular to distinguish fin and blue whales. Cetaceans of 14 species were identified in the survey. These were in addition: sei, humpback, sperm, northern bottlenosed, pilot, and killer whales, a beaked whale, white beaked, Atlantic white sided, likely bottlenosed dolphins and harbour porpoises. The most common large whales were fin whales (890 animals in 556 sightings) and humpback whales (441 animals in 282 sightings).

Icelandic aerial survey
The survey design was identical to that used in 1995 and 1987, except that Blocks 5, 7 and 9 were extended eastward from 11° to 10° W. This was done to achieve better coverage of a major concentration of humpback whales in the area. A greater emphasis was placed on observer training in an effort to avoid some of the problems experienced in earlier surveys. Double platform effort was maintained throughout the survey with the cruise leader, and partially the pilot acting as secondary observers. Realised effort was greater than that achieved in 1987, but less than that achieved in 1995. At least partial coverage was achieved in every block. In all 537 primary sightings of 1,354 animals comprising at least 9 species were made, including 200 sightings of minke whales, 161 of humpback whales and 118 of dolphins.

Norwegian ship survey
The last-minute shift from the North Sea to the Norwegian Sea resulted in problems in co-ordinating the activities of the Norwegian survey vessel. Due to miscommunication very little of the planned effort was

realised. Poor weather affected the second half of the survey. As a result this survey block was not covered. The vessel did however collect surfacing data for minke whales that will be of use in future surveys.

6. MINKE WHALES

i. Ship survey

NASS-2001

No abundance estimate was available for minke whales from the Faroese and Icelandic ship surveys. However the Working Group noted that the coverage and distribution of sightings in the Icelandic survey area may necessitate some non-standard analyses. Because of weather and ice related revisions to the survey plan in the northern and northwestern blocks, the coverage probabilities were substantially higher in some parts of strata than in others. Sightings of minke whales were highly clustered close to the northern and western edges of the western and northwestern blocks, presumably in association with the pack ice edge. This corresponds to an area of high coverage probability. Very few sightings of minke whales were made in the western block, which was mostly surveyed in unfavourable conditions for detecting minke whales (high Beaufort sea state and fog). For these reasons, the Working Group recommended that a spatial analysis be pursued for minke whales and possibly other highly clustered species such as humpback whales. In such an analysis the random placement of transect lines in relation to geographical features is unnecessary. Such an analysis can produce an estimate of greater precision than a line transect analysis, and can provide a better understanding of the underlying distributional patterns of the animals. As a simpler alternative to a spatial analysis, some post-stratification of the original blocks could be pursued.

NASS-95

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 1998a). 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. However the shipboard estimate was apparently calculated at the meeting and was never properly documented. SC/10/AE/6 presented a recalculation of this estimate for archival purposes.

The analysis used standard line transect methods. No double platform data was available to correct for whales missed by the observers. The estimate was calculated using both the original block structure and a post-stratification of block 9 between Iceland and E Greenland to a smaller block that included all the sightings. This post-stratification had been used in the original reported estimate. The total estimates for the survey area and for the survey area outside the aerial survey block were almost the same as those reported in NAMMCO (1998a), irrespective of post-stratification, although there were some minor differences in the individual block estimates and variances. These estimates are negatively biased by both perception and availability biases.

In discussion the Working Group considered that the post-stratification of block 9 was acceptable because it was not based on observed minke whale distribution, but was done in an effort to achieve equal coverage probability in the area close to the pack ice edge. This area is more sheltered that the rest of the block and less effort was discarded due to high Beaufort conditions. The derived estimate will be useful for comparison with similarly calculated estimates from earlier surveys.

ii. Aerial survey

SC/10/AE/5 described an estimate of minke whales from the aerial cue counting survey around Iceland. The survey, conducted in June-July, was the fourth large-scale aerial survey covering Icelandic coastal waters since 1986. Stratified cue counting methods were used to calculate a preliminary estimate of the abundance of minke whales in the survey area. Because of differences in the viewing patterns and sighting efficiencies of the primary observers, 2 estimates were calculated, one using only the better observer, the other using

data from both observers. The best estimate of minke whale abundance in the survey area was derived using only the data of the best observer and a cueing rate of 53 cues per hour (no variance estimate), 40,115 whales (95% CI 24,660 to 65,257) for the entire area. This was about 1.4 times the estimate using both observers, with a slightly higher variance. Double platform effort was maintained throughout the survey, and it appears that the proportion of cues seen close to the survey platform approached 1 for this observer. This estimate may be positively biased by failure to account for error in measuring radial distances. However it appears that distances were measured relatively precisely (CV 8%) so this bias is probably slight. The estimate is higher than that obtained in 1987 and lower than that from 1995. However the lack of data on distance estimation error in 1995 preclude comparison of the 1995 estimate with other years.

The Working Group agreed that the estimate using data from the best observer only was less biased than the estimate using both observers. There is still a need to account for bias due to random error in radial distance measurement, but it was considered that the bias due to this factor is unlikely to be large, given that the observed measurements have an estimated CV of only 8%. A more important factor is likely the cue rate used. Data collected from tagging of minke whales off Norway indicates that the cueing rate there is somewhat lower than the cueing rate of 53 cues per hour used here. This would increase the estimate by proportion. In addition, variance in cueing rate should be incorporated into the estimate.

The Working Group therefore concluded that completion of this estimate will require:

i. accounting for bias due to error in measuring radial distance, and;
ii. use of the best available cueing rate for minke whales during daylight hours, and incorporation of variance in cueing rate in the estimate, and;
iii. using double platform data to correct for perception bias. This may involve analysing the data with respect to where effort appears most concentrated.

It was anticipated that these tasks could be completed within 6 months.

The Working Group agreed that the 1987 and 2001 data should be analysed using consistent methodology that takes account of distance estimation errors.

iii. Combined estimates

As the ship survey estimate had not been completed, no combined estimate could be derived. The Working Group recommended that this be done in a timely fashion.

iv. Trends in abundance

SC/10/AE/7 presented an analysis of trends in distribution and abundance of minke whales from aerial surveys conducted in the coastal waters of Iceland in 1986, 1987, 1995 and 2001. The 1986 survey was conducted as a line transect survey, while the later surveys were conducted as cue counting surveys. The distribution of minke whales was very stable from year to year, with highest densities in the SW, N and SE waters of Iceland. Line transect density was used as an index of relative abundance, and all datasets were treated in an identical manner so that any trend signal would not be masked by analytical differences. Relative abundance showed a significant increase in the area to the N of Iceland, and moderate but non-significant increases in the high-density area in SW Iceland (Faxaflói), NW Iceland and in the survey area as a whole, over the period. The apparent increases in the N and NW of Iceland may be partially due to the cessation of minke whaling, which was concentrated in these areas up to 1985.

In discussion the Working Group noted that an analysis of simple encounter rate would likely give similar results (SC/10/AE/14). The Working Group concluded that the abundance of minke whales around Iceland has been stable or shown a moderate increase over the period. The apparent increase in relative abundance in block 4 is consistent with population growth after cessation of catching, however other factors, such as immigration from other areas, may also be involved. There are also indications of better feeding conditions off northern Iceland in 2001 than in previous surveys.

7. FIN WHALES

i. 2001 ship survey

SC/10/AE/8 described the abundance estimate for fin whales from the Icelandic and Faroese ship surveys. The distribution of sightings of fin whales (see Fig. 3) was more even than in earlier surveys, particularly in the blocks west of Iceland, where the distribution in previous surveys was more concentrated around the continental slopes. Double platform data collected indicated that the proportion of whales seen by the primary observers close to the trackline was close to 1 for this species, and that a correction for whales missed would not increase the estimate substantially while increasing the variance. Estimates by block and for the total area are given in Table 1. The estimate for the total area of 25,352 is higher and has a lower CV than estimates from equivalent areas from past NASS surveys. While some of this increase may be related to increases in survey efficiency, this factor alone likely cannot explain the observed increase since 1987. Stock increase, immigration from other areas, and/or variation in distribution between years may also be involved.

The Working Group concluded that this estimate is likely to be only slightly negatively biased by perception and availability biases, and accepted that correcting for perception bias was not likely to be worthwhile. The four NASS ship surveys carried out since 1987 provide an excellent time series of abundance for this species. It was therefore recommended that a more complete analysis of changes in abundance over all the NASS surveys be conducted. This may require some re-analysis of past survey data as the coverage has changed between surveys.

The Working Group noted that sharing of survey platforms with the redfish survey had apparently been successful. International redfish surveys will be carried out over similar areas on a 3 year rotation, and cover a larger area to the south and west of the NASS-2001 survey area. The Working Group recommended that the possibility of extending the cetacean survey by sharing platforms with the other participating vessels in the redfish survey be further investigated.

Block	Area (nm)	*n*	*L* (nm)	*N*	CV (%)	95% CI	
Icel.SW	190,577	31	1,169	2,723	27.87	1,480	-5,009
Icel.W	154,692	271	2,424	10,800	15.20	7,862	-14,836
Icel.NW	28,154	144	616	5,513	38.81	2,274	-13,370
Icel.N	31,781	38	556	1,522	53.13	449	-5,155
JanMayen	145,847	47	1,791	2,719	38.13	1,196	-6,180
Faroe Isl.	117,500	62	2,457	2,074	27.39	1,139	-3,777
Combined	668,551	593	9,013	25,352	12.71	19,576	-32,831

Table 1. Abundance of fin whales in Icelandic and Faroese ship survey blocks from NASS-2001. *n* - number of fin whale groups sighted; *L* - survey effort; *N* - abundance.

8. OTHER SPECIES

i. Humpback whale

SC/10/AE/9 reported a line transect estimate for humpback whales from the 2001 Icelandic aerial survey. Sightings of humpback whales were highly concentrated off northeastern Iceland and to a lesser extent off southwestern and northern Iceland. A relatively high proportion of sightings close to the trackline by the secondary observers were duplicated by the primary observers, indicating that perception bias is low but not absent for this species. The total number of humpback whales in the search area was estimated to be 3,057

(95% CI 1,727 - 5,410), with NE Iceland accounting for over half of this number. However this estimate has a negative bias because of perception bias and, probably more importantly, animals missed because they were diving when the plane passed. The estimate from this survey is substantially (but not significantly) lower than that produced from the NASS-95 ship survey (Pike *et al.* MS 2001), however this may be due to the above mentioned biases and the fact that the ship survey covered a larger area.

Sightings from the NASS-2001 ship survey were also highly clustered around NE and W Iceland within the aerial survey block, but substantial numbers were also seen in areas farther offshore. More sightings were made in the Faroese block than in previous surveys. No estimate has been derived from these sightings as yet.

In discussion the Working Group noted that the contagious distribution of humpback whales seen in both the aerial and ship surveys may make spatial modelling a suitable analytical approach. It is likely that a spatial model would provide a more precise estimate and might enable some ecological interpretation of the observed distribution. The overlap between the shipboard and aerial surveys may also provide a means of correcting the aerial survey for availability bias, using the ratio of observed shipboard/aerial survey density in the overlap area. However such a correction factor is likely to have a high variance. Another approach might be to use diving data from other areas to correct for availability bias in the aerial survey.

SC/10/AE/14 analysed trend in the relative abundance of humpback whales over the course of the 4 Icelandic aerial surveys carried out since 1986. Encounter rate increased by an average of 11.4% (SE 2.1%) per year over the period in the survey area. Encounter rates for other species did not change much over the period, so it seems unlikely that the increase for humpback whales can be attributed to changes in survey efficiency. This rate of increase is in accordance with that of 11.6% over the period 1970 - 1988 in recorded sightings humpback whales by whalers operating west of Iceland reported Sigurjónsson and Gunnlaugsson (1990).

The Working Group noted that humpback whale sightings have also increased over the course of the NASS ship surveys conducted since 1987, and that much of this increase appeared to have occurred off E Iceland. It was considered useful to break down the trend in the aerial surveys by E and W Iceland to see if the rates of increase differed. It is unlikely that a shift in distribution from offshore to inshore areas can account for this trend as the ship surveys indicate no such shift. Indeed, more offshore sightings of humpbacks were made in 2001 than in earlier surveys.

There has been almost no catch of humpback whales around Iceland since the first stage of Icelandic whaling came to an end in 1915 (Sigurjónsson and Gunnlaugsson 1990). Therefore, stock recovery is one plausible explanation for the trend, however the observed rate is on the edge of biological plausibility. Immigration from other areas may also be playing a role. The Yonah study (Palsbøll *et al*. 2001) has shown that there are at least 2 breeding populations of humpbacks in the North Atlantic, and that the whales around Iceland and Norway are a mixture of the 2 groups. It is possible that the stocks are growing at different rates, accounting for the apparent recent high growth rate around Eastern Iceland.

There has been very little sampling of humpback whales from E Iceland. Víkingsson noted that genetic and photographic sampling was planned for summer 2002, and would be continued if successful.

In summary the Working Group recommended the following with regard to humpback whales:

1. apply spatial modelling techniques to the 2001 aerial and shipboard surveys, and possibly to earlier surveys as well if this proves useful;
2. correct the aerial survey for perception bias using the double platform data;
3. attempt to correct the aerial survey for availability bias using the ratio of observed densities from the shipboard and aerial surveys in areas of overlap, or using diving data from the literature;

4. estimate trends separately in E and W Iceland.

ii. *Lagenorhynchus* dolphins

SC/10/AE/9 reported a line transect estimate for dolphins from the 2001 Icelandic aerial survey. Species identification was uncertain but 96% of the sightings were identified as white-beaked dolphins, with the rest being of unknown species identity. The high proportion of white-beaked dolphins is consistent earlier surveys and other information from the area. The distribution of dolphins was consistent with earlier surveys, with animals being concentrated in N central, SW and SE Iceland, however dolphins were found almost everywhere in the survey area. Group size estimation was somewhat uncertain but there was no apparent bias in group size estimation with perpendicular distance. The total number of dolphins in the search area was estimated to be 20,444 (95% CI 12,714 - 32,874). This estimate is biased downwards both by perception and availability biases. There are duplicate data that can be used to correct for perception bias, but this has not been done yet.

The Working Group recommended that further analyses that incorporate the duplicate data be completed. It was also recommended that the other aerial surveys be analysed in a similar manner to look for temporal trends.

There were large numbers of dolphin sightings in both the Faroese and Icelandic ship surveys. Virtually all sightings in the Faroese block were confirmed as white-sided dolphins. Some of these sightings were in an area in which *Lagenorhynchus* were also seen on the aerial survey. This should be investigated further. Most sightings from the Icelandic vessels were of white-beaked dolphins, but many sightings were not identified to species and it was considered that species identification was uncertain even for those that were identified. Tracking of dolphin groups by the secondary observers was not very successful in either the Faroese or Icelandic surveys, so there is insufficient information to correct for availability bias or responsive movement.

The Working Group reiterated its conclusions from 2000, that while an analysis of the shipboard dolphin data from this and earlier surveys is feasible, the problems of uncertain species identification, uncertain group size estimation, and possible responsive movement of these species would present significant problems for abundance estimation. As a first step, the Icelandic members agreed to inspect the data for these species to determine if further analyses are likely to be useful. If so, an analysis that assigned species identification probability using relevant explanatory variables should be considered.

iii. Pilot whales

A total of 55 sightings of 622 pilot whales was made in the Faroese block, more than in 1995. Sightings were concentrated in the western part of the survey block. The 32 sightings of 563 animals made by the Icelandic vessels were concentrated in the W and SW blocks. Unlike in the 1995 survey when pilot whales were a target species, no closing experiments were conducted to calibrate group size estimation.

The Working Group considered that, given the relatively high number of pilot whale sightings in the 2001 survey, and abundance estimation was worthwhile and should be conducted. Pike agreed to carry out the analysis. It was also noted that a recent successful application of satellite tags in the Faroe Islands will provide data with which to correct for availability bias for this species.

iv. Sperm whales

SC/10/AE/13 presented a calculation of sperm whale abundance from the 2001 Icelandic and Faroese shipboard surveys. For the first time data was collected in such a way that a cue count, using terminal dives as a cue, was feasible. The vessel to stopped or slowed down if it was heading to within 0.5 nm of a sperm whale to avoid triggering responsive cues, and the position of the cue relative to where the vessel would have been had it continued was used in the analysis. In addition to the cue count, which included only those

animals that displayed a cue, a line transect estimate that included those animals that were visible on the surface as the vessel passed abeam was calculated. It was assumed that sperm whales cued twice per hour, and line transect estimate was corrected by assuming that sperm whales spent 20% of the time visible at the surface. For the Icelandic area, the weighted average of the two estimates was 9,477 (CV 0.406). A cue count estimate was not possible for the Faroese area because the positions of terminal dives were not recorded consistently. The ratio between the combined estimate for the Icelandic area, and a line transect estimate that included all sightings (1.41), was used to correct the Faroese line transect estimate to 1,708 whales. The combined estimate for the entire area was 11,185 (CV 0.34). Data from past Icelandic harvests has shown that only male sperm whales are found in these waters.

In discussion the Working Group agreed that the methodology used was theoretically and practically valid. The cue rate and proportion of time spent on the surface used to calculate the estimate are of course crucial. While no data has been collected from this area, data collected from other areas could be applied to provide a better estimate of these parameters. Radio tagging studies in North Atlantic waters will however be required to provide more reliable estimates.

v. Bottlenose whales

More bottlenose whales were were sighted in both the Icelandic and Faroese surveys than in previous surveys. Sightings of bottlenose whales were highly concentrated in the northern Icelandic block, but were well distributed throughout the Faroese block. As NAMMCO has used a line transect estimate from previous NASS surveys in an assessment of this species, it was considered worthwhile to proceed with a line transect estimate for this species, while recognising that it will have a substantial negative bias due to availability bias with this deep-diving species. In this regard the availability of dive data from Canadian waters was noted. Pike agreed to carry out the analytical work.

vi. Killer whales

There were 36 sightings of killer whales in the Icelandic shipboard survey, and 8 in the Faroese block. Most Icelandic sightings were concentrated on one leg in the northern block. It was noted that the animals there appeared to be travelling with the vessel, which may have led to multiple sightings of the same animals. The Working Group considered that an abundance estimate derived from these sightings was unlikely to be of use. However the distribution should be compared with that seen in earlier surveys.

vii. Blue whales

The Icelandic ship survey produced 29 sightings of blue whales, while 9 sightings were made in the aerial survey. While this is likely too few to derive a meaningful abundance estimate, it might be useful to compare encounter rate between surveys to determine if there is any evidence of a trend in relative abundance. However it was noted that such a trend might be confounded by between-survey differences in the effort dedicated to differentiating blue and fin whales. More effort was made to discriminate the species in 2001 than in earlier surveys.

9. EVALUATION OF SURVEY METHODOLOGY

i. Ship surveys

Working papers SC/10/AE/10 and 11 provided evaluations the platforms, equipment, training and methodologies used on the Icelandic and Faroese ship surveys. A major problem with the setup on the Faroese vessel was that the tracker platform was lower than the primary platform. Problems were also experienced with vibration on the tracker platform, making it difficult and uncomfortable to use the binoculars. The primary observers were instructed to search for both the primary species, minke and fin whales, which required them to search at greater distances from the platform than they would have if only minke whales had been targeted. BT design requires the tracker to search substantially further than the primary observers. This requirement was compromised on both the Faroese and Icelandic vessels. Few

trackings of minke whales were made on the Icelandic vessels, probably because weather conditions prevented the trackers from seeing small whales at large distances, and possibly also because the observers tended to focus their search on the target fin whale. The application of the BT method was therefore not successful in terms of correcting for responsive movement and availability bias, although the duplicate data will still be useful in correcting for perception bias, and was felt to be useful in keeping observers alert.

Other more minor problems with the data forms and procedures are summarised in Appendix 4.

In discussion the Working Group considered that the application of the BT methodology was problematic in a combined survey for large and small whales, which did not restrict primary search effort to be substantially closer to the vessel than tracker search effort On these surveys, the BT method was compromised, and few trackings were made. Nevertheless the methodology might have been effective on the Faroese vessel had the tracking platform been higher than the primary platform, and if the problems with vibration had been less severe. It was also noted that tracking small whales at great distances requires experienced and motivated observers, so it is best to ensure that those observers best able to track areused on the tracking platform.

If the BT method was applied as intended, with the primary platform searching close to the platform and the tracker platform searching farther away, it is still likely that sufficient sightings of large whales would have been made.

Another possibility would be to use symmetric platforms, with all observers tracking whales and recording cues and tracking whales, as in the Norwegian minke whale surveys. Duplicate matching would be done after the survey rather than in the field. Initial sightings could be classified by distance to derive corrections for responsive movement and availability bias using the method of Palka and Hammond (2001). Such a methodology would benefit from automated timing of cues, as is done in the Norwegian surveys.. The effort put into tracking might also reduce the total number of sightings, but this might not be problematic as the effort applied is increased by fully utilising the data from both platforms.

The Working Group concluded that the combination of multispecies surveys and BT methodology as implemented in this survey was problematic. However it was emphasised that the double platform methodology in general was successful and will prove useful particularly in refining the estimates for minke whales and other smaller species. Further effort should be devoted to the automation of data recording and entry so that observers can be better monitored by the cruise leader in the field. Finally, special attention must be paid to the design of platforms to reduce vibration, improve visibility and increase observer comfort.

There were problems in conducting distance experiments in these surveys and the Working Group reiterated its previous recommendations that such experiments be conducted during and after the survey.

ii. Aerial surveys

SC/10/AE/12 presented an evaluation of the methodology used in the Icelandic aerial survey, including considerations of survey platform, equipment, personnel, design and strategy, and procedures. A summary of the recommendations for future surveys is contained in Appendix 5.

A more fundamental consideration was whether cue counting from an airplane was the best approach to estimate minke whale abundance in Icelandic nearshore waters. The methodology is very demanding of observers, sensitive to distance estimation error and differences in sighting patterns between observers, although these factors can be accounted for in the analysis.. There have been problems with the conduct (1995, 2001) and analysis of data (all years) from the surveys that make comparisons of absolute abundance between surveys difficult.

In discussion the Working Group noted that cue counting from an airplane should be an effective methodology for minke whales. Correcting line transect estimates for availability bias is more difficult than for doing so for cue counting. The Working Group concluded that with the practical recommendations for improvements in equipment and procedures contained in Appendix 5, cue counting was still the best available methodology for minke whale surveys in this area. Of particular importance will be effective training of observers, and further automation and simplification of the process of data collection, entry and display. It is very important that the cruise leader have the capacity to monitor the performance of observers while the survey is in progress, so that problems can be corrected.

The Working Group agreed that the possibility of using an aerial digital photographic survey should be considered. This technique will be tested in Iceland in the coming year.

10. PUBLICATION OF SURVEY RESULTS

The Scientific Committee had directed the Working Group to devise a plan for the publication of results from NASS-2001 and earlier surveys. It was noted in this regard that none of the results from NASS-95 from the Icelandic and Faroese areas had yet been published. It had been originally planned to publish these results in a volume of NAMMCO Scientific Publications, but that plan had been abandoned.

It was agreed that a special volume on the NASS surveys in general would be of great interest to many researchers. Four NASS surveys have been conducted, over a long enough time frame that temporal trends in distribution and abundance may be detectable. The volume therefore should not merely report abundance estimates from the later surveys, but should synthesise results from all the NASS surveys to elucidate temporal and spatial patterns. It was considered that the volume could best be organised by species, with contributors using information from all the NASS surveys regardless of national affiliation.

Nils Øien and Daniel Pike agreed to take responsibility for organising and editing the volume, to be published as a future issue of NAMMCO Scientific Publications.

11. OTHER BUSINESS

The Working Group will likely need to meet again in winter 2003, once various identified analyses have been completed.

The Working Group expressed their sincere appreciation for the hospitality they had enjoyed at the Fjord and Bælt Centre, and thanked Genevieve Desportes and the Director of the Centre, Heinrich Lehman Andersen, for hosting the meeting.

12. ADOPTION OF REPORT

The Report was adopted on March 15, 2002.

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Pike, D.G., Gunnlaugsson, Th. and Víkingsson, G.A. (MS) 2001. Estimates of humpback whale (*Megaptera novaengliae*) abundance in the North Atlantic, from NASS-95 shipboard survey data. Working paper SC/9/9 for the NAMMCO Scientific Committee.

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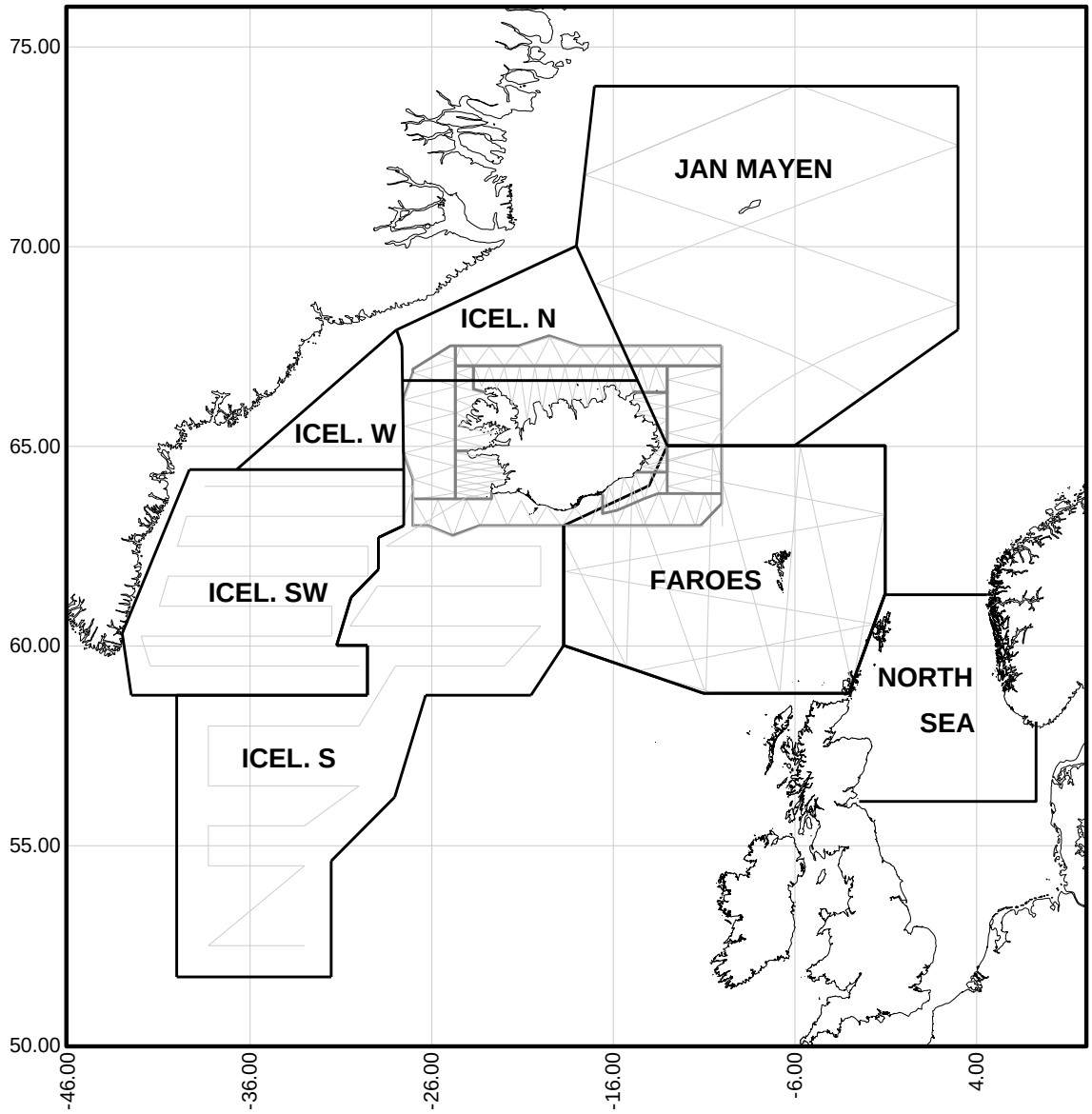

Fig. 1. Planned survey blocks and tracklines for NASS-2001. The North Sea block was not surveyed.

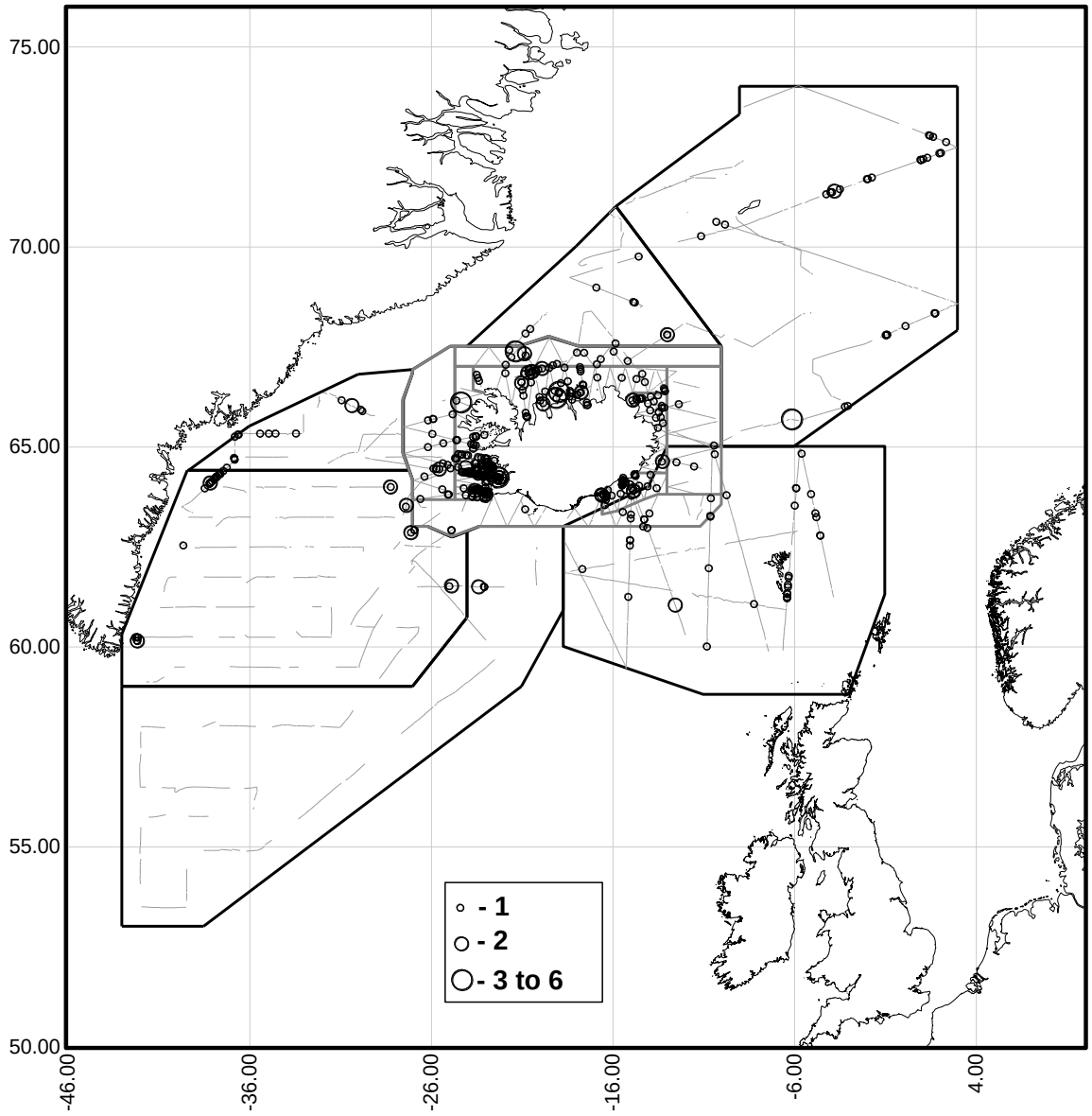

Fig. 2. Distribution of sightings of minke whales from NASS-2001.

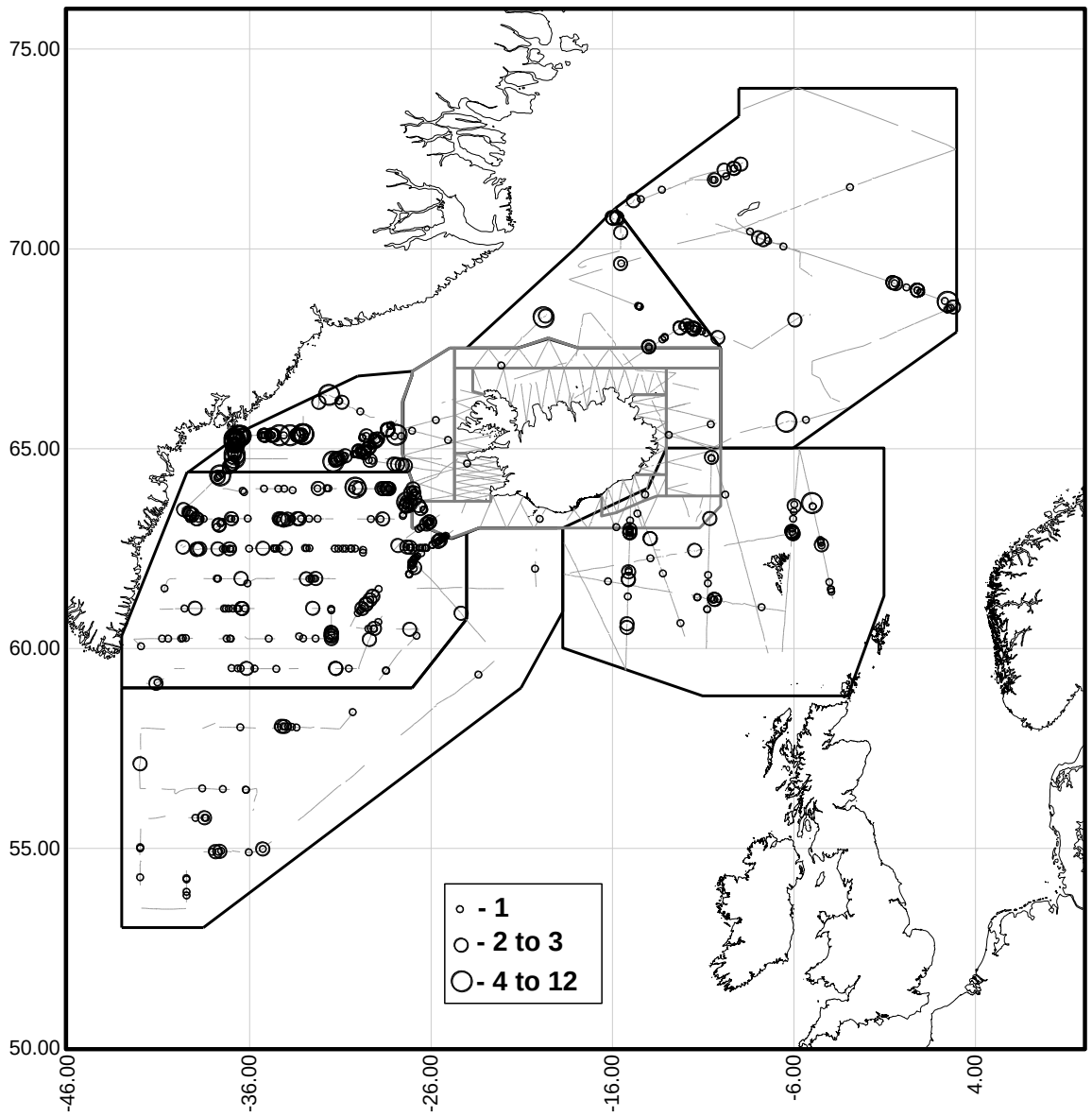

Fig. 3. Distribution of sightings of fin whales from NASS-2001.

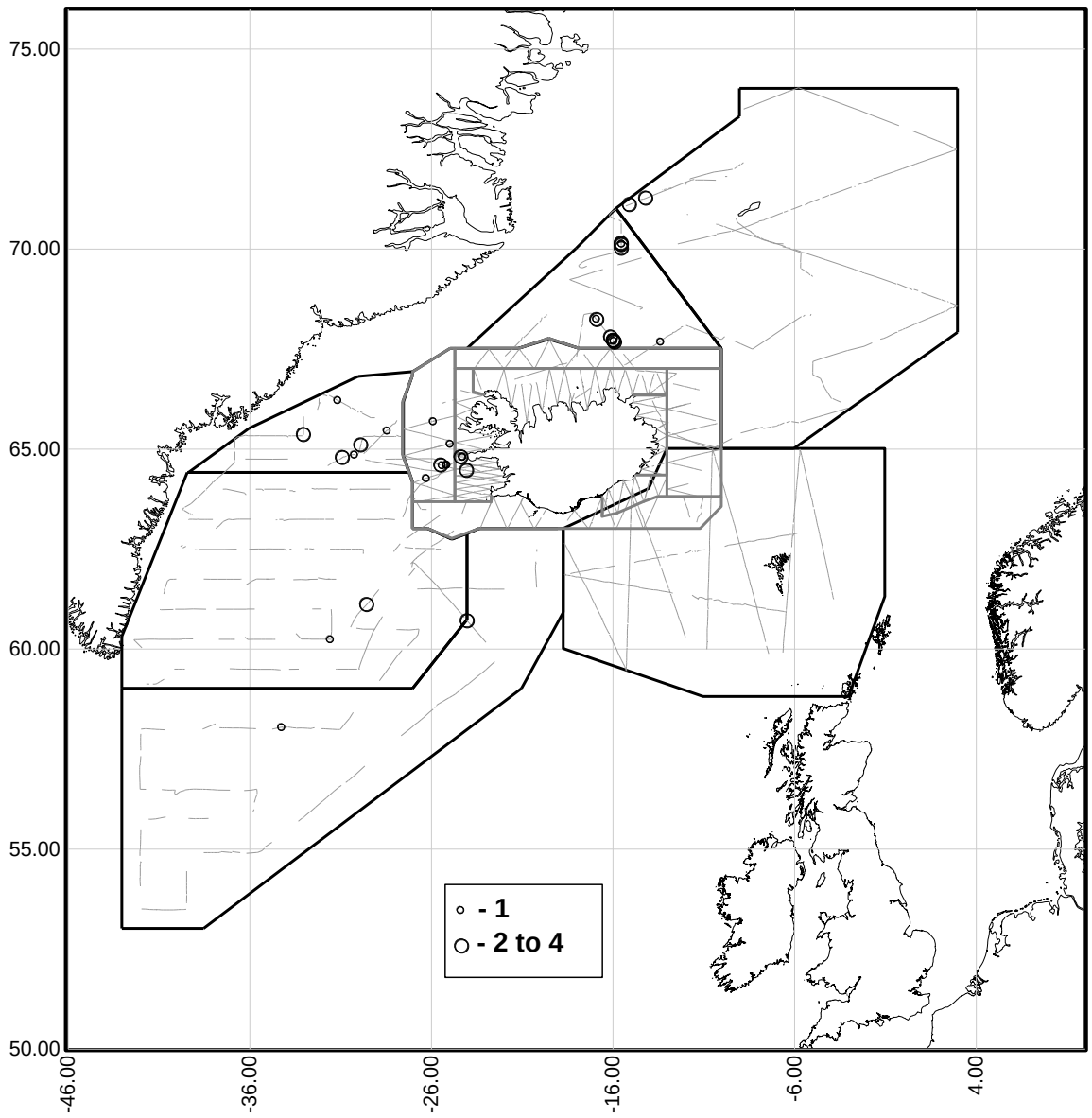

Fig. 4. Distribution of sightings of blue whales from NASS-2001.

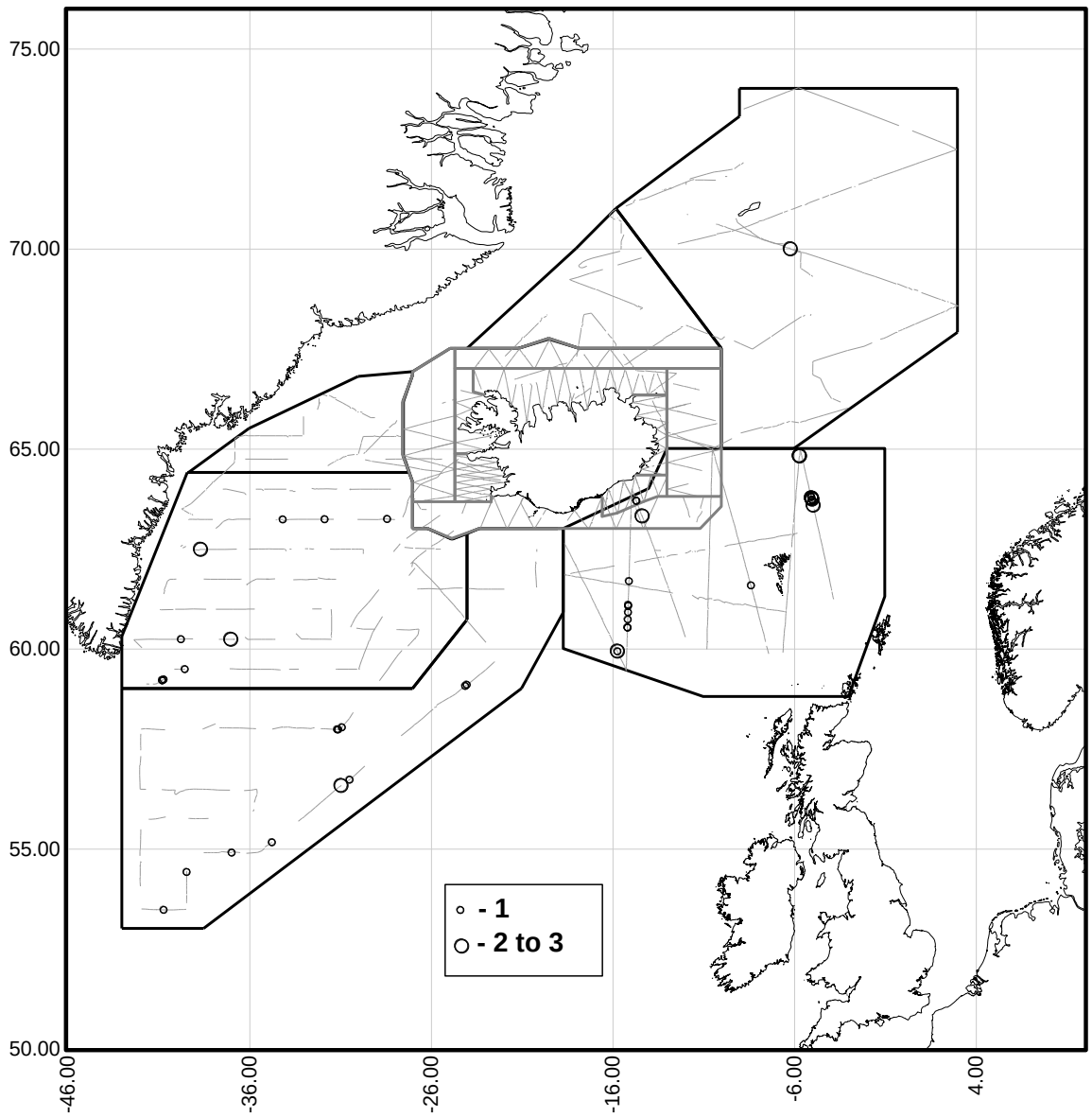

Fig. 5. Distribution of sightings of sei whales from NASS-2001.

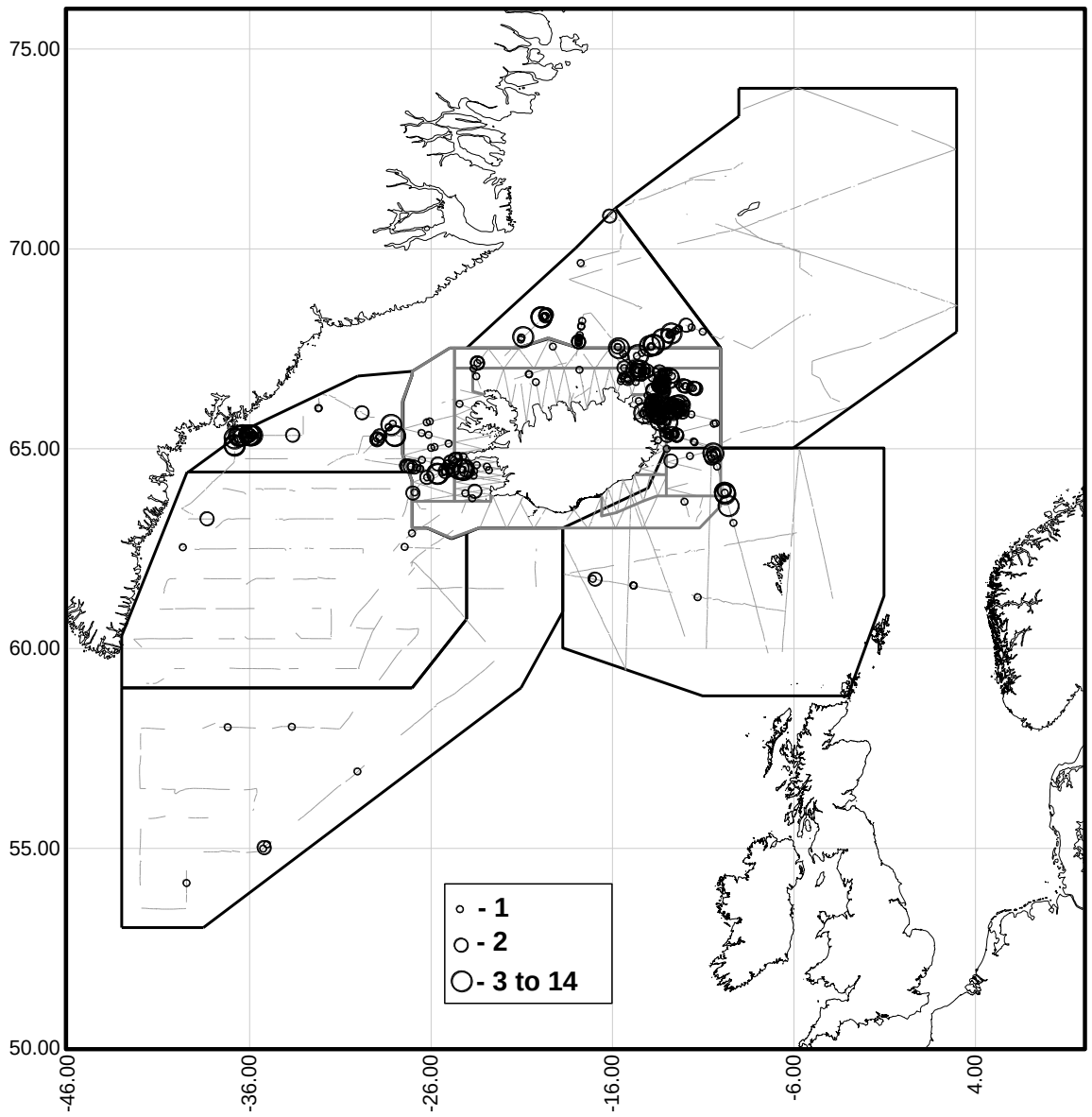

Fig. 6. Distribution of sightings of humpback whales from NASS-2001.

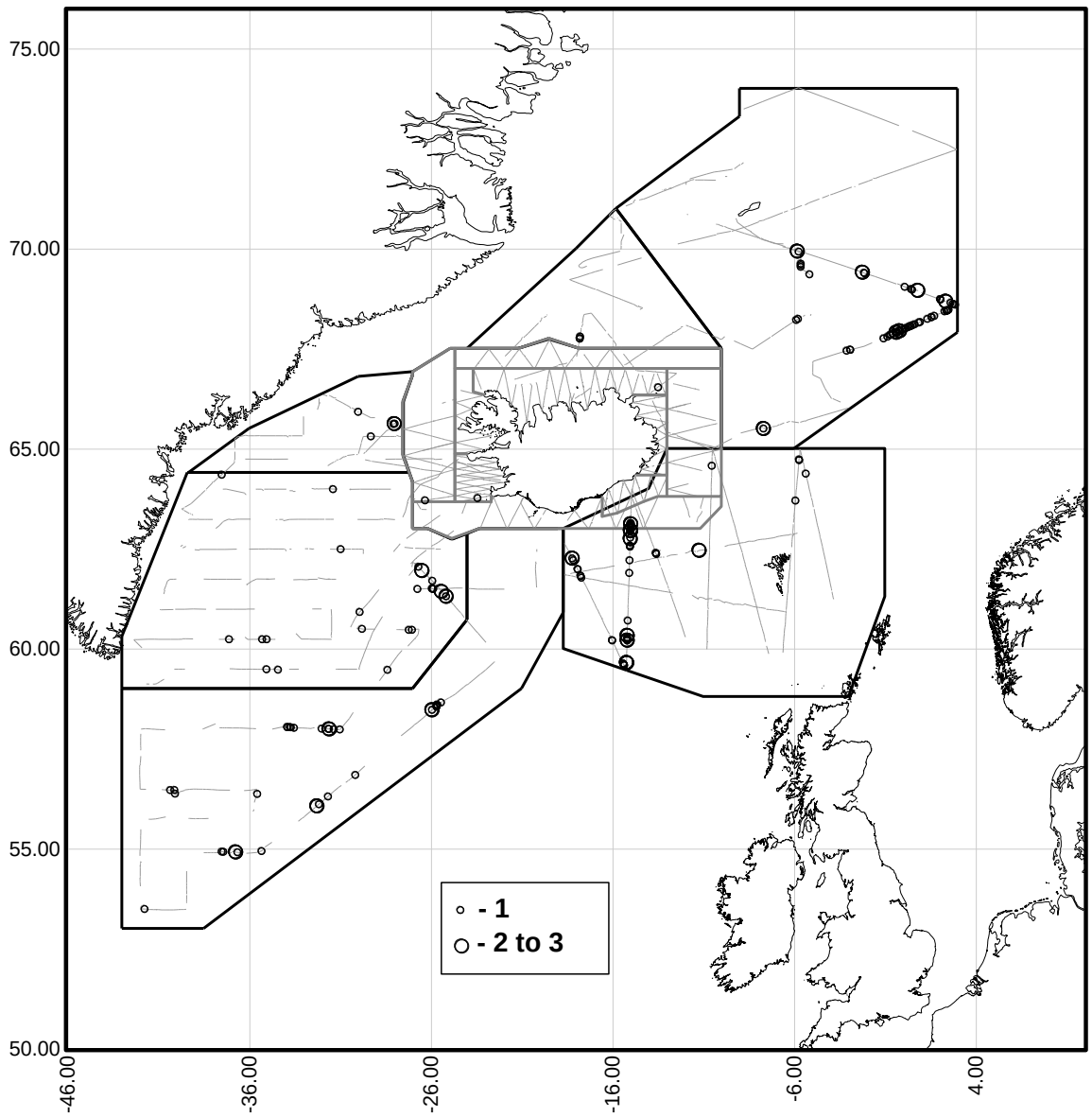

Fig. 7. Distribution of sightings of sperm whales from NASS-2001.

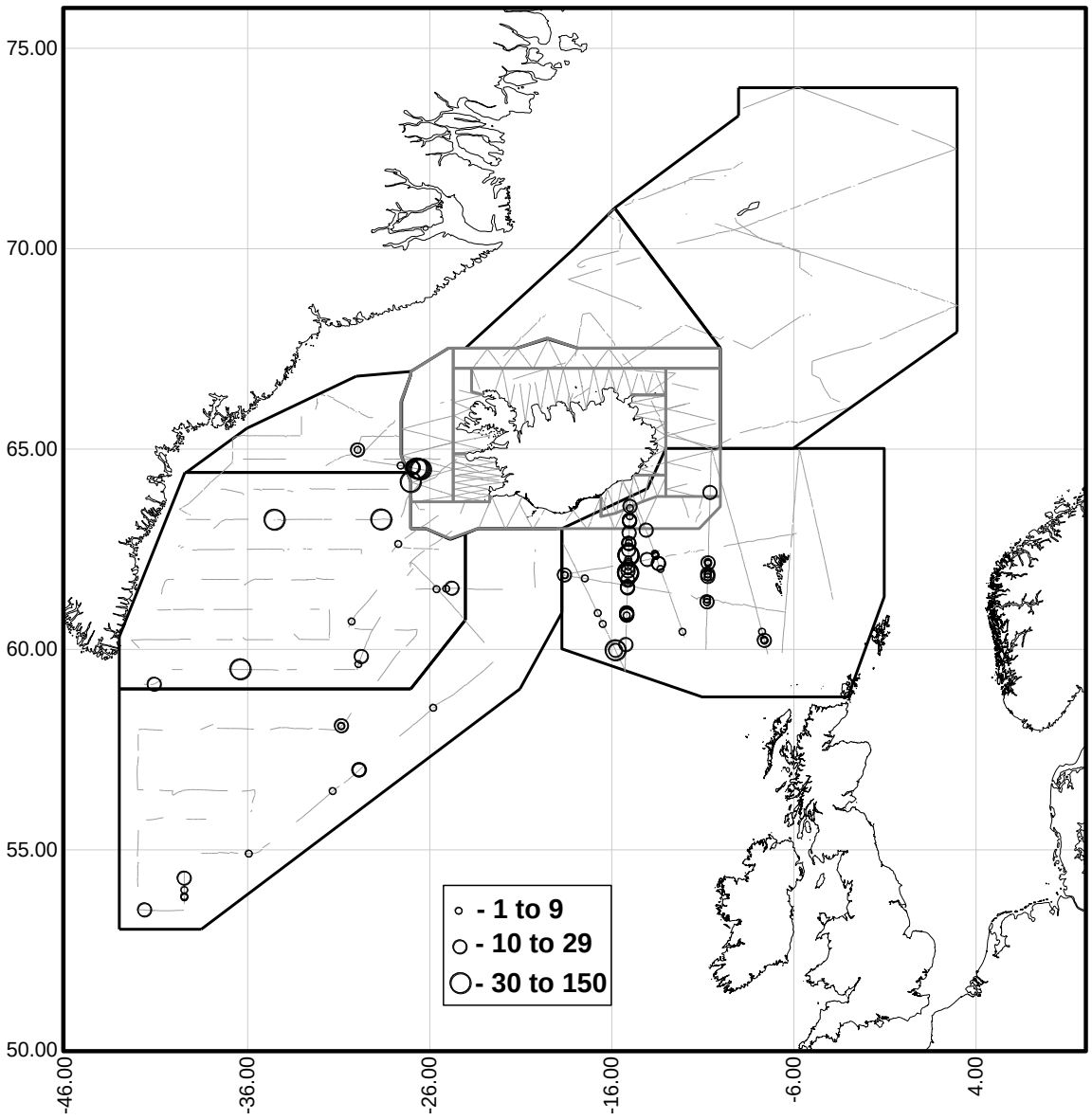

Fig. 8. Distribution of sightings of long-finned pilot whales from NASS-2001.

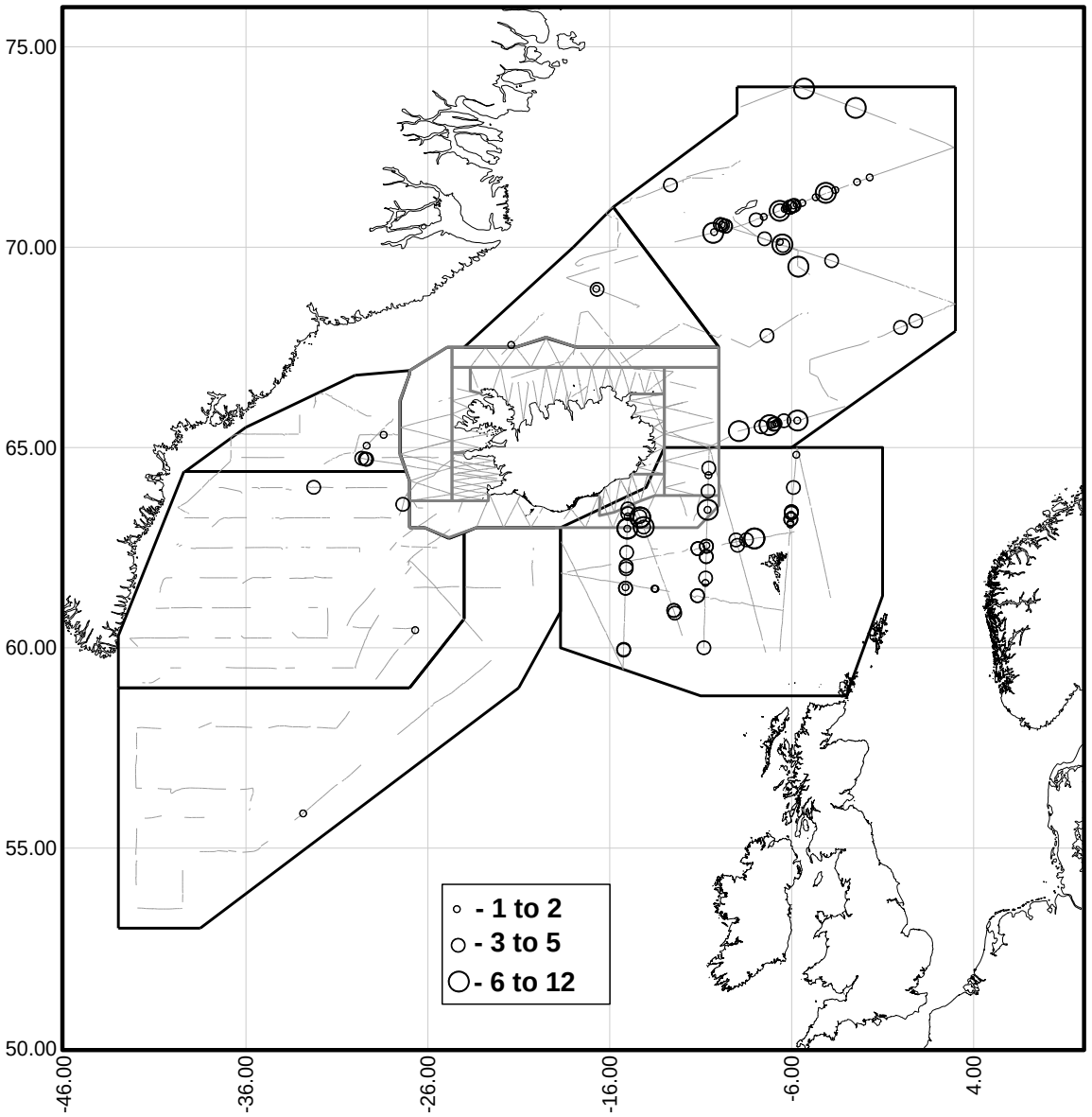

Fig. 9. Distribution of sightings of northern bottlenose whales from NASS-2001.

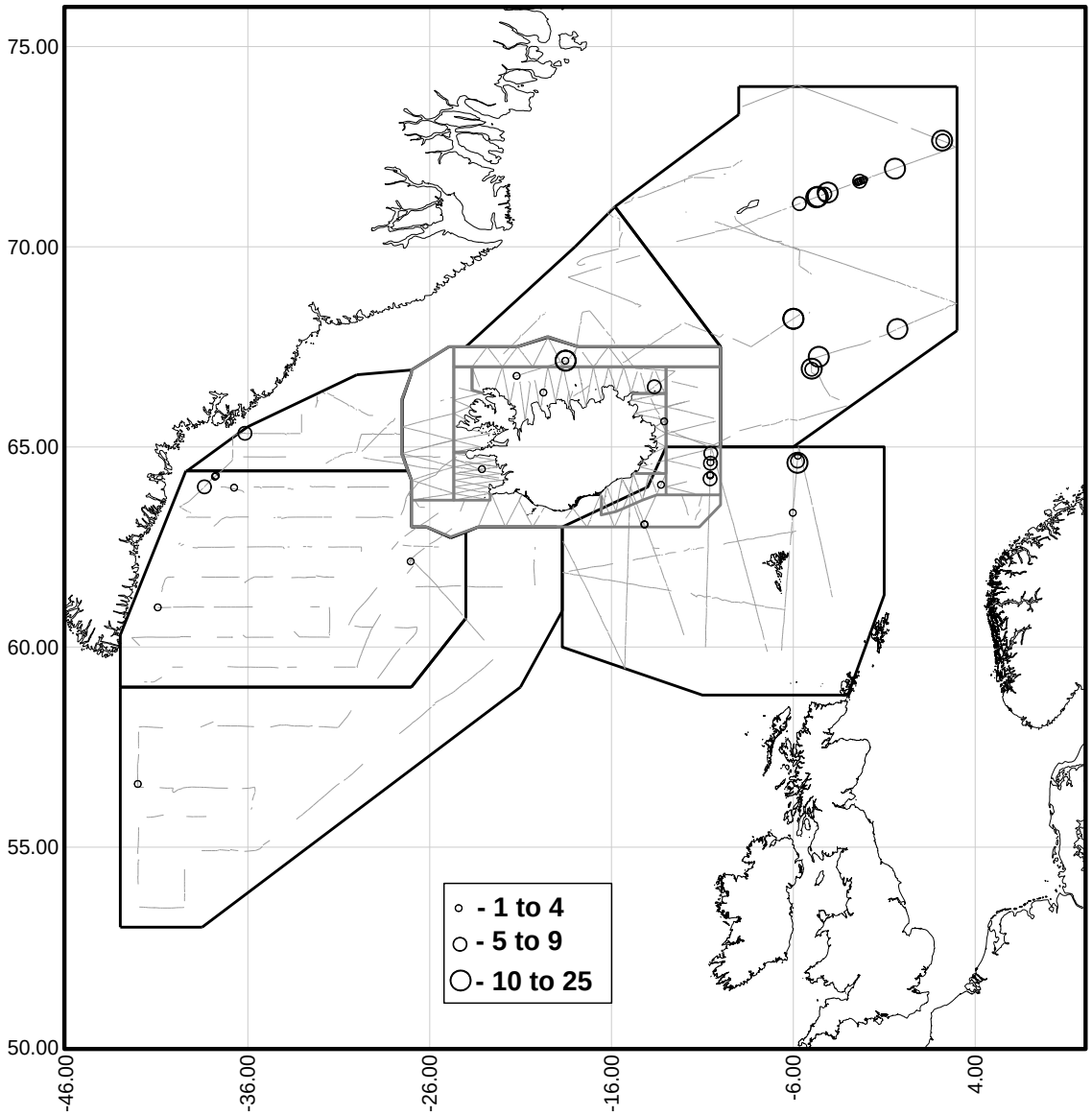

Fig. 10. Distribution of sightings of killer whales from NASS-2001.

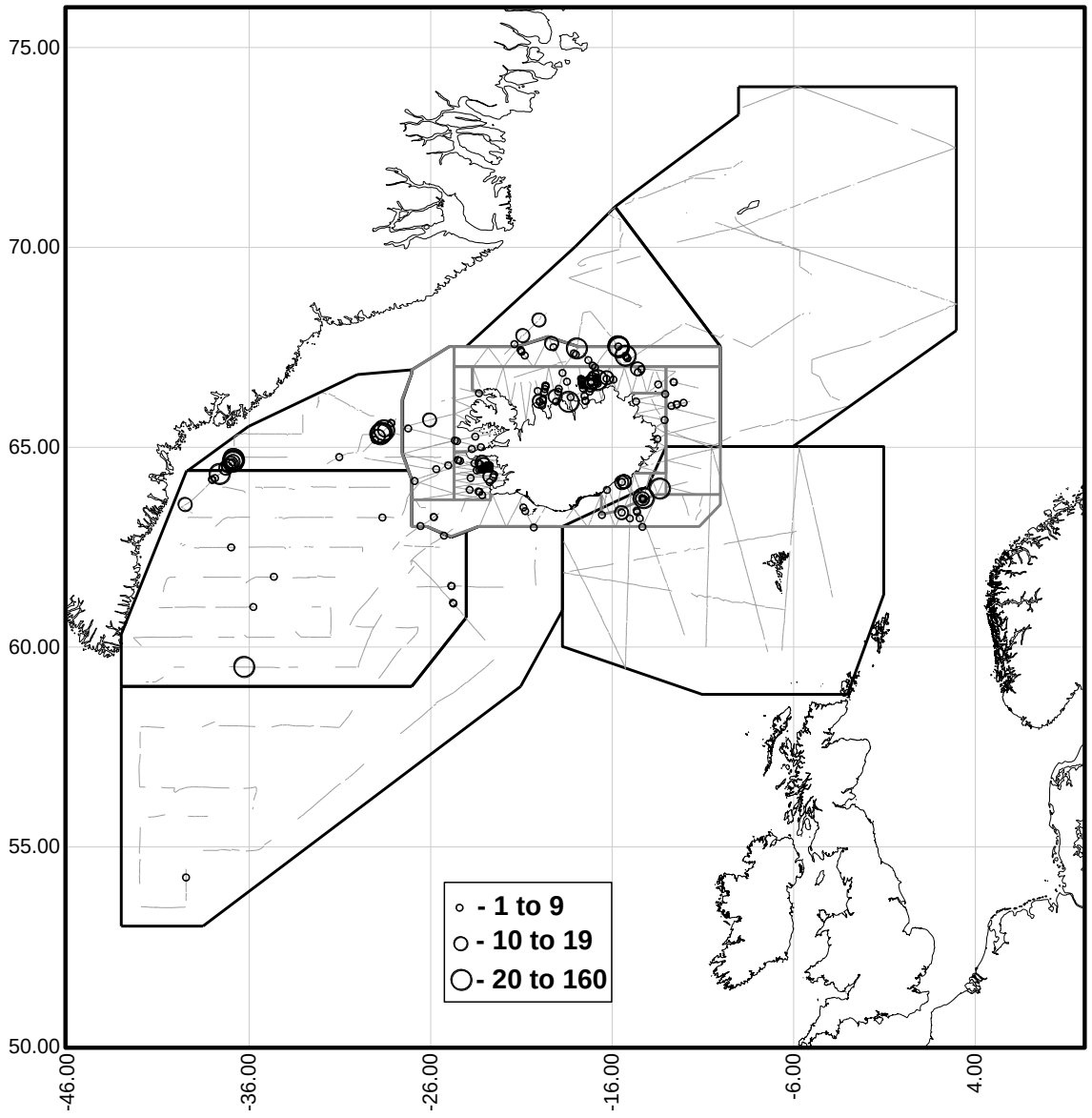

Fig. 11. Distribution of sightings of white-beaked dolphins from NASS-2001.

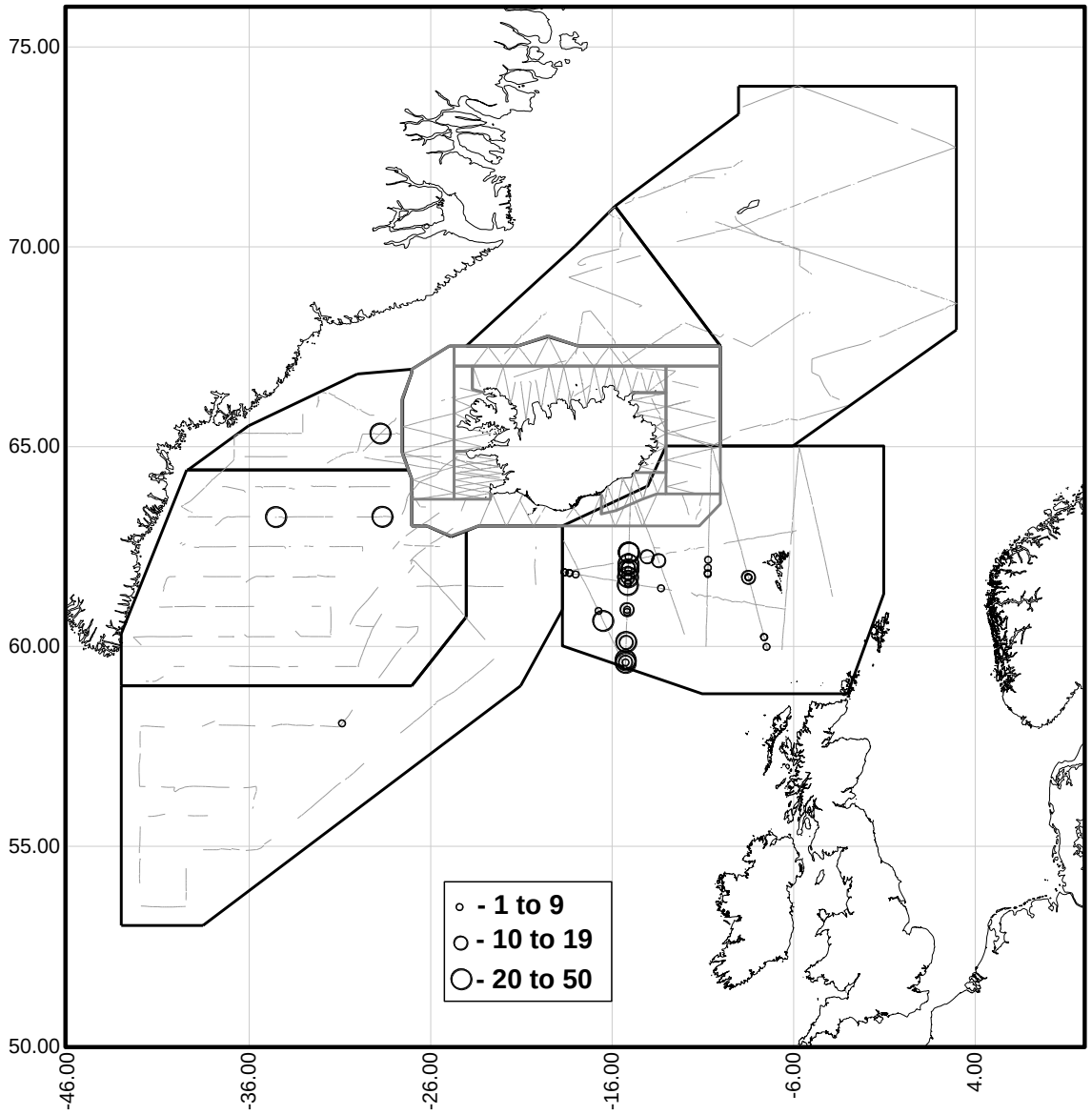

Fig. 12. Distribution of sightings of white-sided dolphins from NASS-2001.

Appendix 1

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Appendix 2

AGENDA

1. Opening remarks

2. Adoption of Agenda

3. Appointment of Rapporteur

4. Review of available documents and reports

5. Survey reports

6. Minke whales
   - ii. Ship surveys
   - iii. Aerial survey
   - iv. Combined estimates
   - v. Trends in abundance

7. Fin whales
   - i. 2001 ship survey
   - ii. Combined estimates
   - iii. Trends in abundance

8. Other species
   - i. Humpback whale
   - ii. *Lagenorhynchus* dolphins
   - iii. Pilot whales
   - iv. Sperm whales
   - v. Bottlenose whales
   - vi. Killer whales

9. Evaluation of survey methodology
   - i. Ship surveys
   - ii. Aerial surveys
   - iii. Recommendations for future surveys

10. Publication of survey results

11. Other business

12. Adoption of report.

Appendix 3

LIST OF DOCUMENTS

Document No.	
SC/10/AE/1	List of participants
SC/10/AE/2	Draft agenda
SC/10/AE/3	Draft list of documents
SC/10/AE/4	Not available
SC/10/AE/5	Pike, D.G., Gunnlaugsson, Th. and Víkingsson, G.A. A preliminary estimate of the abundance of minke whales (*Balaenoptera acutorostrata*) from the NASS-2001 Icelandic aerial survey
SC/10/AE/6	Pike, D.G., Gunnlaugsson, Th. and Víkingsson, G.A. A re-calculation of the abundance of minke whales (*Balaenoptera acutorostrata*) from the NASS-95 Icelandic ship survey.
SC/10/AE/7	Pike, D.G., Gunnlaugsson, Th. and Víkingsson, G.A. Trends in the distribution and relative abundance of minke whales (*Balaenoptera acutorostrata*) from NASS Icelandic aerial surveys, 1986-2001.
SC/10/AE/8	Gunnlaugsson, Th., Víkingsson, G.A., Pike, D.G., Desportes, G., Mikkelsen, B. and Bloch, D. Fin Whale Abundance in the North Atlantic, Estimated from Icelandic and Faroese NASS-2001 Vessel Surveys.
SC/10/AE/9	Pike, D.G., Gunnlaugsson, Th. and Víkingsson, G.A. Preliminary estimates of the abundance of humpback whales (*Megaptera novaengliae*) and *Lagenorhyncus* spp. dolphins from the NASS-2001 Icelandic aerial survey.
SC/10/AE/10	Gunnlaugsson, Th., Halldórsson, S.D., Ólafsdóttir, D. and Víkingsson, G.A. NASS 2001 Icelandic shipboard survey report
SC/10/AE/11.	Desportes, G. An evaluation of the methodology used in the NASS-2001 Faroese ship survey.
SC/10/AE/12	Pike, D.G., and Víkingsson, G.A. The NASS-2001 Icelandic aerial survey: Introduction and evaluation.
SC/10/AE/13	Gunnlaugsson, Th., Víkingsson, G.A., Pike, D.G., Desportes, G., Mikkelsen, B. and Bloch, D. Sperm whale abundance in the North Atlantic, estimated from Icelandic and Faeroese NASS-2001 shipboard surveys
SC/10/AE/14	Trends in humpback whale (*Megaptera novaeangliae*) sightings rates from aerial surveys in Icelandic waters during 1986-2001.

SC/10/AE/15 Desportes, G., Mikkelsen, B., Bloch, D., Danielsen, J., Hansen, J. and Mouritsen, R. Survey report from the Faroese shipboard survey of NASS-2001.

Appendix 4

RECOMMENDATIONS FOR IMPROVEMENT OF THE NASS SHIPBOARD SURVEYS

(Compiled from SC/10/AE/10, SC/10/AE/11 and comments at the meeting)

Vessels, platforms and equipment

1. Vessel AF2 should be fitted with an extra outdoor tracking platform around or below the present one.
2. The tracking platform should be at a higher elevation than the primary platform.
3. Every effort should be made to reduce vibration that interferes with the use of mounted reticule binoculars on the tracking platform. This should be tested before the survey begins, and modified if necessary.
4. The platforms should be placed in such a way that they do not obscure the radar. This creates problems in conducting distance experiments.

Procedures

1. The importance of recording re-sightings should be stressed.
2. The special protocol for sperm whales must be further elaborated. It is very important that the ultimate fate of each sighting be recorded, i.e. was it observed when abeam? Where was it last see? What effort/speed/heading changes were made prior to the last sighting?
3. Observers who prefer to use binoculars and are talented at picking up sightings at long distances should be used as trackers.

Data forms and data recording

1. Cloud coverage ahead should be recorded as percentage separate from weather codes for mist and rain. Cloud coverage should be categorised as high or low cloud.
2. Swell height should be recorded as 1 digit, m, and wave length as 2 digits, m.
3. Cue type should be recorded in mnemonic codes.
4. Record movement as: H, T, X = head or tail, L, R, S = side.
5. Use ISO8606 standard for date and time.
6. Missing codes: flipper as cue, wind direction, closure and confirmed sightings, code for likely duplicate between platforms, code of qualifying success of closure.
7. Use decimal points, not commas, in all records.
8. Procedures for data entry and display should be streamlined, so the observers can be better monitored by the cruise leader. Simple software should be developed for daily display of angle and distance data. More automation of data recording would be useful, for example time and angle of sighting.
9. Recording of meteorological data should be automated.
10. The recording of echosounder data periodically throughout the survey should be considered.

Training

1. More effort should be dedicated to observer training, and some ship time should be used. Several days of land training, followed by 1 to 2 days of training/experimental survey at sea would be ideal. The observers should understand how the data will be used, so they will understand the importance of strictly following survey procedures.

Other

1. Request permission to enter any other countries territorial waters at least 6 months prior to the survey.

Appendix 5

RECOMMENDATIONS FOR IMPROVEMENT OF THE NASS ICELANDIC AERIAL CUE COUNTING SURVEY

(Compiled from SC/10/AE/12 and comments at the meeting)

Survey design and strategy

1. The offshore blocks are often difficult to complete because of weather. In future surveys the idea of covering these blocks by ship should be considered. It might also be possible to have some flexibility in the ship survey design, so that it could cover some of the offshore aerial blocks if necessary. This would require close communication between the aerial and ship survey teams. It could be decided beforehand that if a block had not been completed by the last week of the survey, it would be re-assigned to the ship survey.
2. The survey crew must be flexible and mobile, and able to move at short notice to areas of Iceland that have suitable survey weather.
3. Weather forecasting services should be used to choose an area where surveying might be possible. The crew should then contact the Icelandic "Coast Guard" to obtain telephone numbers of fishing vessels in the prospective survey area, then contact the vessels in the area to get an on-the-spot account of the conditions. In doing this, one must remember that a fisherman's idea of "good" weather may be quite different from that required for survey. The Captain should be asked to describe the waves he is experiencing, not just to report the Beaufort sea state.
4. A general prioritisation plan for the blocks, rated on minke whale density, would be:
   i) Blocks 1, 4 and 8;
   ii) Other inshore blocks: 2, 6 and 9;
   iii) Offshore blocks: 3, 5 and 7.

Of course this prioritisation scheme will be different if other species (e.g. humpback whales and dolphins) become more important in future surveys.

Platform and equipment

1. A lighter, less bulky system, that records voice and data directly on the computer hard drive, is required. It should be designed so that it is possible for more than one person to transcribe data simultaneously (using separate computers).
2. Data acquisition and entry should be further automated so that it is feasible for the cruise leader to view displays of angle and distance data on a daily basis, in order to monitor the observers properly. Alternatively, a non-flying crew member should be dedicated to data transcription and data entry during the survey.
3. Sightings close to the platform are of course most important in both cue counting and line transect methodologies. The use of an observer at a belly window should therefore be considered.
4. An electronic declinometer with a digital display should be tested and used if it performs adequately. This should be easier to read quickly than the analog models.
5. A method of directly measuring or more easily and accurately estimating angle from the nose of the airplane to the sighting should be developed.

Procedures

1. The use of double-platform methods should be considered an absolute necessity in these surveys. The Cruise Leader can observe full-time if he/she records all environmental observations verbally rather than using paper forms.
2. A special protocol should be developed for the pilot, which would allow him/her to record his/her sightings verbally without taking measurements, preferably with the use of a voice-activated microphone.

The pilot would be instructed to describe his/her sightings as they occur, including estimations of declination and head angle.

3. The primary and secondary platforms should be visually isolated from one another. This can be easily achieved with the use of a curtain.
4. To achieve aural isolation of primary and secondary observers, the observers should be instructed to hold the recording microphone close to the mouth and to speak only as loudly as required to make an audible recording. The intercom microphone should be pushed out of the way while on effort
5. Consideration should be given to using 3 primary observers on the flights, and rotating them approximately every 30 minutes, or between survey legs, so that each observer would have a 30 minute rest after every hour of observation. This would reduce the risk of observer fatigue affecting sighting efficiency on long flights.
6. It is important for the primary observers to change seats at least every day and preferably more frequently, for variation in seating position and so that all combinations of primary - secondary observer are used.
7. The observers' data should be transcribed and entered electronically on a daily basis. This would allow the cruise leader to examine the angle, location and distance distributions of the sightings, to make sure the observers are covering their areas adequately, and not favouring certain angles or areas in the sighting field. This will require changes in equipment (see above).
8. Sitting in one position for hours on end can be extremely uncomfortable, and this increases observer fatigue and reduces the effectiveness of the observers. The observers should be encouraged to use pillows or other means to increase the comfort of their observing stations.
9. If dolphins are a priority in future surveys, closings should be made on a subsample of dolphin groups to confirm species identification and calibrate group size estimation.
10. If cue counting (as opposed to line transect) methods are realistically expected to be of use for humpback and other whales, the necessity for the observers to count blows should be emphasised. Otherwise, the protocol should be changed such that the observers are instructed simply to count groups of whales as in a line transect.

Observer training

1. Observer training is extremely important. At least 2 days of ground training and 5-10 hours of in-flight training are required.
2. A general training plan is as follows:
   i. Class training- survey plan, theory, data forms, etc.
   ii. Ground training. Conducted in the plane, on the ground. Observers record sightings of targets dragged under the wing of the plane. Subsequently, they go over the recordings and transcribe the data. Problems with procedures are identified and the process is repeated.
   iii. In-flight training. Conducted over Faxaflói Bay in a 2-3 hour flight. Should be done in full survey mode. Afterwards, the observers go over their recordings and transcribe their data. Problems are identified, and the process is repeated if necessary.

Other

1. It would be extremely useful to apply satellite tags to minke whales in the same area and simultaneous with the survey. This would give time/place specific estimates of cueing rate and surfacing times that could be of use in a cue counting or line transect survey. It could also provide an estimate of inter-block movements over the course of the survey, and could provide data with which to estimate $g(0)$ by attempting to sight tagged whales.
2. The feasibility of a digital photographic survey, as an alternative to cue counting, should be investigated.

Annex 2

MODELLING MARINE MAMMAL - FISHERIES INTERACTIONS IN THE NORTH ATLANTIC

Workshop Report

Reykjavík, 13-15 September, 2002

1. OPENING REMARKS

Chairman Lars Walløe welcomed the members (Appendix 1) to the Workshop, and summarised the background to the present Workshop.

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 in estimating consumption by these species. It also considered the use of multi-species 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 a workshop to further investigate the methodological and analytical problems in estimating consumption by

marine mammals. This workshop resulted in concrete recommendations to estimate consumption by North Atlantic marine mammals, and a list of research priorities to refine existing estimates (NAMMCO 2002).

The Scientific Committee views the next logical step in this process to be a review of how presently available ecosystem models can be adapted for quantifying marine mammal - fishery interactions. Several different candidate models have so far been identified: the Icelandic BORMICON, the Norwegian MULTSPEC and Scenario Barents Sea, and the ECOPATH/ECOSIM model. The properties of different models will be discussed and compared, as well as the desired spatial and temporal resolutions. The Workshop is tasked with choosing a preferred modelling approach for analysing the ecological role of minke whales, harp and hooded seals, and other marine mammal species in the North Atlantic, identifying required input data and its precision, and recommending a process for further development of the model. Lack of knowledge of important input data will also be identified. An important consideration will be predator choice of prey given a range of available prey and prey densities. The Chairman emphasised that the Working Group should not expect to review results or make quantitative predictions at this meeting, but should rather focus on methodological problems.

2. ADOPTION OF AGENDA

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

3. APPOINTMENT OF RAPPORTEUR

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

4. REVIEW OF AVAILABLE DOCUMENTS

Documents available to the Workshop are listed in Appendix 3.

5. PROGRESS AFTER THE 2001 NAMMCO WORKSHOP

Analysis of NASS-2001 data continued within the NAMMCO Scientific Committee Working Group on Abundance Estimates (See Annex 1). Preliminary estimates have been calculated for fin, sperm and humpback whales. New abundance estimates on the most important species including minke whales will be finalised in 2003.

Haug reported on recent research carried out in Norway on harp and hooded seals and minke whales:

- Collections to continue the time series on minke whale diet and body condition performed during commercial whaling in the North Sea, Barents Sea and around Spitsbergen.
- A new abundance estimate (based on sightings surveys in 1996-2001) for Northeast Atlantic minke whales is now available.
- Ecological studies (diets, body condition) of harp and hooded seals in pack ice waters of the Greenland Sea in the period between moult and breeding (July-February) had been continued. Modelling of total consumption of the two Greenland Sea stocks, based on new data and experience from similar work in the Northwest Atlantic and in the Barents Sea, is in progress.
- Abundance of Greenland Sea harp seals were assessed using aerial strip transect methods to estimate the 2002 pup production.
- Assessment of Barents Sea harp seal predation on resources in open waters are in progress: aerial surveys to map the distribution of seals are performed simultaneous with ship borne surveys designed to estimate the abundance and distribution of capelin.
- Demographic and ecological (primarily body condition) data collected seals from taken in the commercial hunt.

Víkingsson reported on recent research in Iceland:

- Sampling of stomach content of hooded seals in Icelandic waters was continued in 2002.
- Laboratory analysis of material sampled from bycaught white-beaked dolphins off Iceland is nearly complete.

Mikkelsen reported on recent research in the Faroe Islands. In the Faroes a scientific sampling programme was initiated in 2001 on white-sided dolphins taken in the traditional hunt.

The Chairman and others present reported that the Scientific Committee of the International Whaling Commission had held a workshop on a similar theme in La Jolla, California in June 2002. It was planned that the report from that meeting should be available [in confidence, pending its submission to the IWC] for this workshop in order to avoid duplication of effort, however the report has not yet been completed. The Chairman summarised some of the results from the meeting for the group. A general conclusion from the meeting was that interactions between marine mammals are a topic worthy of quantitative scientific investigation. The workshop investigated several candidate models, including MULTSPEC and ECOPATH/ECOSIM.

6. INTRODUCTION TO MULTI-SPECIES MODELS

The Working Group considered descriptions of the range of available multi-species modelling tools. This includes two general classes of models typified by the Minimum Realistic Models (MRM) on the one hand and the ECOSIM/ECOPATH approach on the other. The MRM class includes MULTISPEC, BORMICON/GADGET and Scenario Barents Sea. These models share the characteristics of being system specific, modelling only a small component of the ecosystem for a specific purpose, and treating lower trophic levels and primary production as constant or varying stochastically. In contrast, ECOPATH/ECOSIM is an all-inclusive approach that incorporates lower trophic levels and primary production.

i. Minimum Realistic Models - Doug Butterworth

The concept of Minimum Realistic Models was first introduced in the context of evaluating the potential impact of a then expanding fur seal population on the important fishery for hake off the west coast of South Africa at a Benguela Ecology Programme Workshop on Seal-Fishery Biological Interactions held in Cape Town in 1991 (Butterworth and Harwood 1991). The implementation of the approach to this problem is detailed in Punt and Butterworth (1995).

The key feature of the MRM approach is that consideration is restricted to species considered likely to have important interactions with the species of interest, Cape hake in this instance. Thus, in addition to the impact of fisheries, the model included seals and a grouping representing large predatory fish. Together with the effects of cannibalism and inter-species predation for the 2 hake species, the model then accounted for over 90% of the natural mortality of hake. The different components of the model were described at the level of detail considered necessary to capture key aspects of the dynamics: thus fully age-structured models were used for the 2 hake species to capture cannibalism and inter-species predation effects accurately, whereas the grouping of other predatory fish was modelled in a lumped fashion by only 2 linked components of small and large fish.

The analysis was set within the simulation framework of a 20 year projection under a feedback control rule for setting TACs for the hake fishery, to ascertain whether possible increases in the sustainable yield of hake in response to a seal cull might actually be realised. The robustness of the results obtained was checked by repeating the simulations for variants of the underlying MRM that involved primarily consideration of alternative values for parameters whose magnitude was uncertain.

In this initial implementation of the approach, the work had proved complex and lengthy. This, however, was seen as a consequence of the complexities of age-structured modelling of hake cannibalism and inter-species predation in this instance, rather than necessarily a general feature of the approach.

Discussion
The Working Group noted that since the models of this type provide a partial view of the ecosystem, the cost of ignoring un-modelled, weak ecosystem links should be assessed. More research in this area is required, possibly using simulation studies involving both strong and weak ecosystem links.

The approach as applied to the Benguela ecosystem demonstrated the requirement for ecosystem-specific models. A generic approach could not have captured the unique dynamics of even this rather simple ecosystem model. Any model is likely to require a large amount of work to adapt it to a particular area. Generalised modelling approaches must be very flexible and have accessible, easily modifiable coding so they can be adapted to specific situations.

ii. MULTSPEC - Sigurd Tjelmeland
MULTSPEC, which was established at the National Institute of Marine Research in Bergen, is a general-purpose multi-species simulator for the Barents Sea. It was initially designed to be a tool for calculating the spawning biomass of capelin, but later interactions between fish and marine mammals were included. At present the species capelin, cod, herring, polar cod, minke whales and harp seals are modelled.

The original application could be handled fairly rigorously since the general features of the migration were known – the capelin has to cross the entire population of immature cod to spawn every year and since there is a survey on immature cod during February, yielding not only the geographical distribution of cod but also a large quantity of stomach samples of cod.

When marine mammals were added rather counter-intuitive results were obtained. There proved to be a larger gain in the cod fishery by removing the seal population from the model than by removing the whale population, even if the whales eat more cod. Also, decreasing the suitability of herring as food for cod had a larger effect on the yield from the fisheries than removing the marine mammals altogether. The reason for this lies with the cod-herring-capelin dynamics. In order to get the marine mammals – fish interactions right the fish-fish interactions must be right.

At present MULTSPEC is resting and there has not been active work on this model for several years due to lack of resources. An attractive alternative for a geographically structured simulator for the Barents Sea is to implement the GADGET model. In addition simpler models are needed, like the Scenario model developed at the Norwegian Computing Centre. In view of the scarcity of resources this model should preferably be cast into the GADGET code.

In addition to these general-purpose simulators or simulators tailored to the marine mammals – fish issue, it is interesting to include consumption by marine mammals in fish assessment models. At the IWC cetaceans – fish workshop in La Jolla this year an attempt was made to include predation of Norwegian spring spawning herring by minke whales in the assessment model SeaStar. In the short term predation of capelin by harp seal will be included into the assessment model for capelin – Bifrost – on an experimental basis.

Discussion
It was noted that a version of MULTSPEC was being adapted for use in the western Pacific ecosystem by Japan, but no information on this effort was provided to the workshop.

The idea of including marine mammal predation in traditional single species assessment models such as Bifrost was considered a useful avenue of research by the Working Group. This should improve the performance of these models if predation by marine mammals is a significant component of natural mortality. In addition it will have the added side effect of increasing the demand for effective modelling of marine mammal predation, thereby assisting in the development of the scenario models of most interest to this group.

The rationale for including marine mammals in models, in preference to other predators such as seabirds, was discussed. It was considered that marine mammals would be a more productive focus for modelling in the candidate areas because the magnitude of their consumption is much greater than that of seabirds (Barrett *et al.* 2002). In addition, more and better data are available for marine mammals than for seabirds in the regions of interest.

The use of marine mammal populations as indicators of general ecosystem health was discussed by the Working Group. For some species, such as harp seals, there is a large amount of historical data on abundance and productivity, which could be correlated with fishery assessment and possibly climatic data. It was noted that Russian scientists are pursuing this with harp seals, and that marine mammals are used as indicators in the Antarctic. However it was considered that in most cases it will be easier to monitor the ecosystem components of interest, such as fish stocks, directly, rather than relying on an indirect indicator such as marine mammals. There may be significant time lags in the response of population parameters to ecosystem change in long-lived marine mammals. In addition, adaptive prey switching may mask significant ecosystem changes, as has been noted for both harp seals and minke whales.

iii. Scenario Barents Sea - Tore Schweder

Scenario Barents Sea is a series of projects at the Norwegian Computing Center in Oslo with extensive help and advice from Institute of Marine Research in Bergen and Tromsø. The two first projects were carried out from 1993 to 1999, while a new project funded by the ministry of Fisheries will be carried out in the period 2002-2004. In this new project harp seals will be included in the model. The aim is to study how various management strategies for sealing and whaling will affect the Norwegian fish-fisheries, on the basis of our current knowledge and data concerning the population dynamics of, and interaction between, harp seals, minke whales, cod, herring and capelin. Another aim is to identify holes in our knowledge, and pressing data needs.

The previous projects compared management strategies for cod and herring (Hagen *et al* 1998); studied direct and indirect effects of minke whale abundance on cod and herring fisheries (Schweder *et al* 2000a); studied the effects on these fisheries of re-tuning the IWC/RMP for minke whales (Schweder *et al* 1998); and also compared management strategies with respect to long term resource rent, harvest capacity, catch, and abundance of cod (Schweder *et al* MS 2000b).

When studying the interaction between management of marine mammals and fish, the model in the previous projects has 4 species: cod, capelin, herring and minke whales. The fish populations are age and length distributed, while the minke whale is age and sex distributed. The time step is one month, and there are two areas (The Barents Sea and parts of the Norwegian Sea). There is a food-web with minke whales as top predators, consuming herring, capelin and cod according to a non-linear consumption function in available prey abundance. The consumption function for minke whales is roughly estimated. The opportunistic minke whale may forage on plankton and other fish than cod, capelin or herring, and is modelled as having carrying capacity and demographic parameters independent of the status of the fish stocks in the model.

The fish-fisheries are managed by fixed VPA-based fishing mortalities (cod and herring) and CAPTOOL (capelin), while minke whaling is managed according to the Revised Management Procedure (RMP) of the IWC (Schweder *et al* 1998). The model is stochastic in fish recruitment and in survey indices for minke

whales. The model is simulated over 100 year periods in a number of scenarios spanned by 9 experimental factors. The core of the experimental design is an orthogonal array with 27 points. The primary study variable is the tuning of the RMP, and the response variables are catches and stock sizes of cod, herring and minke whale. The responses are taken as yearly means over the last 90 years of the period.

When the tuning of the RMP is changed from the current level of targeting the final stock at 72% of carrying capacity to 60%, the annual catch of whales increases with some 300 animals, while the annual catch of cod increases with some 0.1 million tons on the average. For herring, no clear main effect was found on catch or mortality rate. The catch of cod is estimated to increase in annual mean with some 6 tons when the whale stock is reduced with one animal. Schweder *et al.* (MS 2000b) found further that minke whale abundance affects the cod fishery in a similar linear fashion over a wide range of minke whale abundance. The results concerning the effects on the cod and herring fisheries must be taken as tentative since the ecosystem model used could be improved, and so could the strategies for managing the fisheries.

Discussion

The Working Group noted that the lack of data on some aspects of the model, particularly the response of predators to prey availability, had led the modellers to use plausible ranges rather than estimated values for some parameters in the model. While this was considered to be acceptable in a scenario testing model such as this, the sensitivity of the model to these parameters needs to be thoroughly assessed. Also, the lack of data on these parameters should be used to identify research priorities to fill in the gaps in knowledge.

Fishers are assumed to tailor their catches to quota decisions in some of the versions of this model, and no "economic behaviour" of fishers is included. Economic behaviour is, however, included in one version of the model. Although outside the scope of fish-marine mammal interaction, it was found of considerable interest that Schweder *et al* (MS 2000b) found that quota capping could produce substantial gains in the economic performance of the fishery, accompanied by a strengthening of the stock.

The fact that minke whales and harp seals were included as exogenous components of the model, so that their population parameters were not affected by changes in prey availability, was considered problematic by some members of the Working Group. Changes in harp seal condition, productivity and migration patterns have been associated with the collapse of the capelin stock in the Barents Sea in the 1980s, which apparently resulted in the "seal invasions" of the Norwegian coast. While it was considered that there is evidence to show that there are responses in seal fecundity and survival rates in response to food availability, there are insufficient data to model these responses at present, and they could be included in the model only with very great uncertainty. No such responses have been demonstrated for minke whales. Nevertheless the Working Group concurred that inclusion of endogenous responses to prey availability where such responses have been demonstrated would make the model more realistic.

The model is incomplete and does not include all the major predators of cod, herring and capelin, or even all marine mammal predators. If minke whale predation is reduced, it is possible that other predators, such as dolphins, killer whales or seals, may respond by increasing their abundance and predation pressure on these species. Therefore it was considered important that the main top predators are included in simulation models such as this. This will be difficult because the predators will have to be included as endogenous components that respond to competition by other predators. The functional relationships to model these responses are simply not available for most species, and certainly not for dolphins for which very little information is available. This should be considered a caveat in the use of models in which the top trophic levels are not completely specified. To include harp seals would help. But, if harp seals are exogeneous to the fish system, a reduction in minke whales will not allow harp seals to respond to the accompanying availability of food. It is therefore good reasons to make the harp seal an endogeneous component in the model. Schweder responded that attempts would be made to collect the information necessary to model the response of harp

seals on fish abundance, and that the aim is to complete the model in this respect. Whether this could be done in the project Scenario C is however uncertain.

The linearity of the response of cod and herring catch over a wide range of minke whale abundance was considered surprising by the Working Group. It was originally thought that the removal of herring by minke whales would improve the survival of juvenile capelin, thereby enhancing the productivity of the cod stock, however this effect was not observed in the simulations. However the observed response is heavily dependent on the functional response to prey availability by minke whales, and data on this are poor. The meeting recommended that the sensitivity of model output to different assumptions for the form of functional response should be investigated.

Scenario – GADGET perspective

The new scenario project aims at updating the existing scenario model for the Barents Sea and the Norwegian Sea with improved predation structure and population structure. The project has limited funding, and will not accomplish much more than putting together the currently available data and knowledge in the existing framework, and to carry out simulation experiments.

The long term goal however is to transport the various components of the model to the system GADGET, and to build the model further in this system, at least when the GADGET allows the Scenario model to be used as a testbed (operating model) for management procedures. This will have a number of advantages. Some of these are:

- GADGET is likely to be better documented than the Scenario program and is expected to be better maintained and improved.
- With a general and openly available system tailored to fisheries, the Scenario model is likely to be more transparent when implemented in GADGET than in the present C-code.
- In the GADGET system a data warehouse is available. This enables unified and easy access to fisheries data at appropriate levels of aggregation, which facilitates future updating of predation functions and other aspects of the model.
- Future data might allow migration patterns to be estimated for the various stocks. Implemented in GADGET, the Scenario model might model the spatial overlap explicitly.
- GADGET is general, and does not set limits to the number of components. In a GADGET implementation additional species such as like killer whale or shrimp might more easily be included.

For the future development of the Scenario model, parts of the model could be run over the Internet. This would enable models of subsystems to reside in their home institutions, and be improved and updated there.

iv. BORMICON/GADGET - Gunnar Stefansson

The first data-driven multi-species models to be applied to fisheries data, such as MSVPA[1], did not include any statistical techniques but used ad-hoc methods for estimating parameters. Since these models only included predation mortality but not the effects of consumption on the growth of the predators, they had some serious shortcomings in terms of applications to Arcto-boreal systems given the highly variable growth in these systems, sometimes attributed to variation in food availability. Further, since there are no spatial

[1] MSVPA is a multispecies extension of Virtual Population Analysis (VPA). VPA involves estimation of annual recruitments to a fish population by summing fishery catches-at-age up for each cohort while at the same time making allowance for losses to natural mortality (M) each year. In standard VPA, M is customarily taken to have a constant value, independent of year and age. Multi-species VPA performs this estimation simultaneously for a number of species. The important extension to standard VPA is that consumption by a predator species is explicitly included in the computation of natural mortality losses for the corresponding year and age for the prey species in question, so that M for each species becomes both age- and year- dependent. These computations are based on diet composition studies.

features in MSVPA, it is at best difficult to account for highly variable spatial overlap of predators and their prey.

The first such model to be applied to Arcto-boreal systems, MULTSPEC, addressed some of these shortcomings by being a spatially explicit model. MULTSPEC also applied statistical estimation methods through the use of likelihood functions, albeit in a rather limited sense. MULTSPEC was also fairly specific in terms of what were prey and predators, making additions and model changes somewhat difficult.

When initially developing models for Icelandic waters, a decision was made to address all of these issues at the design stage. The first model, BORMICON (A BOReal MIgration and CONsumption model) was a multi-species, spatially dis-aggregated model which took into account growth as a function of consumption and allowed the user to specify their preferred likelihood functions. A deliberate design issue was to be able to accommodate quite different components of population dynamics models and different likelihoods for different species and data sets, thus allowing for varying levels of knowledge and different data collection schemes. Thus a fairly generic environment for model development was designed, rather than a single model. This environment is a flexible platform for models (or model components) of biological processes. Although a model implemented in GADGET can be quite complex, this is inevitable when testing complex hypotheses. It is simply not possible to evaluate the importance of temporal - spatial overlap without explicitly taking these into account.

BORMICON was subsequently used as a basis for FLEXIBEST for assessments of Northeast Arctic cod. The various developments have been co-ordinated as a European project with a current program (2000 - 2003) which includes models such as the initial FLEXIBEST and BORMICON as special implementations. It is important to note that any specific growth models, suitability functions etc. are intended to be modules, with alternative formulations easily added.

Within the European framework, the goals were to: Obtain a model/tool which describes the most important features of the system as it relates to fish; Understand the models/limitations; Understand the underlying multispecies dynamics; but not at this stage to obtain an assessment toolbox.

The current program, GADGET (Globally Applicable Area-Disaggregated Generic Ecosystem Evaluation Tool), is a fully parametric forward simulation model (and can therefore in principle be run without any data). A simulation results in population trends by species, size class, age group, area and time step. These trends can subsequently be compared to data using appropriate likelihood functions, eventually maximising the likelihood functions to obtain parameter estimates.

Consumption within GADGET is modelled using suitability functions and mortality can be due to predation, other natural causes or fishing.

Growth is implemented via movement up through length classes and can depend on consumption, with several growth update mechanisms already available.

Migration is implemented through movement matrices. In principle these can vary by time step, but in typical case studies they are assumed to be fixed in time.

The species life cycle has not been closed within GADGET at present so spawning, as currently implemented, only results in weight loss. It is foreseen that during the coming year the first models with a closed life cycle will be tested, with larval drift of fish implemented through exogenous hydrography-driven movement matrices.

The model is completely symmetric across species and areas so that, for example, a predator's behaviour is defined only through associated data sets and parameterisation.

Parameters are estimated using maximum likelihood. These likelihood functions are sometimes quite difficult and can be multi-modal due to several reasons, requiring global minimisation algorithms for initial estimation, followed by local minimisation algorithms which zoom in on the minimum. Given that individual simulations can require considerable computing power, a parallel minimisation algorithm has been designed.

A number of likelihood functions have thus been implemented but recent work indicates that many common data sets defy the most common statistical assumptions. It has also been seen that model "stiffness" implies that too much weight given to a data source (i.e. incorrect likelihood function) can lead to widely varying population trends, which is in stark contrast to well-known results in linear statistical models where incorrect variance assumptions tend to be of minor significance.

Since GADGET is a parametric model, it can in principle run without data. For data-poor species, highly detailed models which require large numbers of parameters cannot be reasonably implemented and the modeller is forced to use simpler models with fewer parameters. For some marine species highly detailed data are available and these can then be used to fine-tune highly detailed models.

Given the data requirements, it is obvious that if data is entered into GADGET data files by hand or using manual extractions from raw data bases, revisions of spatial aggregations or length groupings will require considerable revisions of the data files. For this reason a data warehouse has been defined in such a way that it consists of mildly aggregated data in standardised tables. Extraction routines for assessment purposes have been written and extraction routines for GADGET are under development.

Current case studies within the European framework include Icelandic waters, the Celtic Sea and North Sea herring. For each of these areas a multi-species model is being implemented using GADGET with data extracted from standardised tables in each area.

Current implementations include several species within Icelandic waters (single species, single area up through 3-species in 10 areas), and Barents Sea cod. In spite of known problems, the program is currently used for assessments in several cases where no alternatives exist to account for known important processes within the system.

Future work includes obtaining reliable estimates of uncertainty, implementations of tagged sub-populations, development of new likelihood functions and closing the life cycle. The most promising approach to estimating uncertainty appears to be bootstrapping but considerable work is needed in this area, given the correlated nature of the measurements.

Discussion

The Working Group was impressed with the scope and ambition of this project in attempting to establish a framework for ecosystem models of various levels of complexity. When put to use, the GADGET system will provide a strong and unified platform for data handling, scenario modelling and simulation, and model fitting. Such a unified platform is certainly welcome, and so is the information technology that is put together in GADGET. However, even with good information technology as GADGET, much work remains for the particular modelling exercises. Scenario- and assessment models are necessarily case specific, and all the specifics must be worked out for each particular case.

It was noted that marine mammals have not been included in any of the GADGET case studies to date. Earlier attempts to include cetaceans in multi-species modelling in Icelandic waters (Stefansson *et al.* 1997) have shown that more data on diet of minke whales is required for the Icelandic area.

The simultaneous maximisation of likelihood for up to hundreds of parameters in non-linear models is problematic due to local maxima and other difficulties. To allow the parameters of the model to be fitted simultaneously to the collection of relevant but fragmented data is highly desirable, but very taxing. In GADGET, global maximisation is carried out, which was applauded. However, with a highly non-Gaussian likelihood, the information matrix is not particularly informative of the statistical properties of parameter estimates. One intermediate course would be to fit parts of the model to relevant parts of the data, and then to reserve only a limited number of parameters for the final simultaneous fitting. The other parameters would then be kept constant at their partial estimates. In the discussion, it was pointed out that when a sound likelihood function is available, the scene is set for valid parametric bootstrapping. Statistical measures of uncertainty in conclusions are thus much better obtained by bootstrapping than by calculating the Hessian at the computed maximum.

The scope for a Bayesian approach to quantifying the uncertainty in conclusions was also mentioned. This might be possible through simulation when well-argued prior distributions are available.

v. ECOPATH/ECOSIM

ECOPATH is an equilibrium approach to multi-species modelling. Mass balance equations are used, essentially relating production by some species to predation by others under the assumption that the system is in a steady-state. Unlike the models discussed above, ECOPATH also considers the lower trophic components of the ecosystem, for example plankton. ECOSIM builds upon this approach, but drops the equilibrium assumption so that the system is modelled by a set of coupled differential equations. Attempts had been made to have a scientist experienced with applications of ECOPATH and ECOSIM to make a presentation to the meeting, but unfortunately without success.

Discussion

Potentially ECOSIM could provide a basis to provide advice on marine mammal-fisheries interactions. An advantage of the package is the structured framework it provides to setting out species-specific inputs required for multi-species modelling. Potential disadvantages discussed included the built-in functional forms for species interactions, and simplified treatment of age-structure, that may not be appropriate for the particular cases to be considered. Another problem is the large number of parameter values that need to be specified; some of these may have an appreciable impact on outputs, and the default suggestions provided by the package may not be the most appropriate in all circumstances. Furthermore, ECOSIM is at the other end of the spectrum of possible models compared to the single species approaches currently used as the basis for management advice, in the sense that it attempts to model all elements of the ecosystem. A less expansive approach, building from single-species experience and without immediately attempting to incorporate phyto- and zooplankton dynamics, might be more appropriate as an initial advance from current practice.

7. PREY SELECTION PROCESSES

Prey selection by minke whales in the Barents Sea – Ulf Lindstrøm

To elucidate the prey selection function of minke whales, Norwegian Institute of Fisheries and Aquaculture performed studies of minke whale foraging dynamics in selected areas in the southern Barents Sea in 1998 and 1999. Stomach contents were sampled onboard commercial whaling vessels whereas the resource availability was assessed using standard acoustic surveys by research vessels. Three different approaches were applied to make inferences about minke whale selectivity:

1. Chesson's selectivity index,

2. Multivariate statistics
3. Empirical Bayesian statistics.

The first approach involves use of the bootstrap, i.e., the index was calculated for each prey type and then tests were carried out to look for deviations from random feeding. This was done by calculating approximate 95% confidence intervals for the expected index value for each prey. These were compared with the expected index value on the assumption of random feeding. The prey availability was estimated by bootstrap sampling of assumed independent resource samples.

The second approach involves constructing multivariate confidence bounds (ellipsoids) to delimit expected prey proportions in the diet and the environment and thereby reveal significant differences. For the diet analysis, the bootstrap was applied to obtain precision measures of the dietary prey proportions, whereas in the spatial analysis of prey densities, intrinsic geostatistics were applied; statistically homogenous conditions are assumed. Because whaling and resource sampling were not simultaneous, the whales may have experienced different resource availability than observed during the resource mapping. To account for this uncertainty, the variation between realisations of the prey density process was included in addition to the sampling uncertainty for each realisation.

The methods applied in the two previous approaches were based on extensive use of the bootstrap, but since use of the bootstrap is strongly dependent on a sufficient number of independent samples, a simplified binomial model was applied to the diet analysis with special emphasis on capelin. The expected proportion of capelin in the diet was estimated as the number of whale stomachs dominated by capelin divided by the total number of non-empty stomachs. For a given capelin proportion in the sea (q), the p-value can be found by a classical method. That is, the simulated distribution of capelin proportions in the sea, provided by the methodology in previous approach, was considered the *a priori* distribution for the unknown q. The appropriate p-value was the defined as the mean in the posterior distribution of p conditional on q

The prey selectivity of minke whales was analysed over various levels of spatial resolution, which turned out to be important considering the results from three consecutive resource surveys performed in one small-scale area. The spatial pattern may change rapidly, particularly with respect to pelagic shoaling fish such as capelin and herring.

It was concluded that there is an apparent advantage of multivariate over univariate comparisons of prey preference when strong prey correlations are involved in the diet and the environment. Accordingly, if the sample size is sufficiently large, the multivariate approach is recommended. On the other hand, with few whale samples the Bayesian statistical approach seems promising.

Discussion

Haug noted that large scale spatial and temporal correlations between prey abundance and minke whale diet have been observed. In years when strong year classes of juvenile herring area available, herring can dominate the diet in areas where the distribution of minke whales and juvenile herring overlap. The proportion of capelin in the diet also tracks capelin abundance to a large extent.

Studies of the type presented provide estimates of prey selectivity at the microscale. However, multi-species models require estimates of such consumption functions at the macroscale (the spatio-temporal scale of the strata adopted for the population dynamics modelling). Conversion of the results from microscale experiments on selectivity to yield macroscale estimates is not straightforward, as the results will depend on the spatio-temporal distributions of predators and their different prey species, and the former may alter in response to changes in the latter. In the short to medium term, the prey selectivity values needed for multi-species models will likely need to be based on the aggregated approach of regression analyses relating observed changes in annual average predator diet to varying prey abundances provided by assessments -

hopefully such data will provide sufficient contrast to allow for reasonable estimates to be obtained by this approach. Nevertheless, detailed, smaller scale efforts should be continued to elucidate the mechanisms behind prey selectivity, and to allow the conversion approach to be applied in the longer term. It was noted that a potential problem with the aggregated approach was the non-random nature of the diet data, which is dependent on samples taken from the commercial hunt. There is evidence from sightings surveys and incidental observations that whales occur in areas where they are rarely hunted. While a randomised sampling program to obtain diet samples would be preferable, it was considered highly unlikely that this could be realised in the near term.

The available data on minke whale diet covers a limited seasonal window, and this could confound the estimation of consumption functions. Most diet data comes from commercial whaling in May and June, and there is almost no data from the rest of the year. In addition, catch locations from commercial whaling conducted after the 1950s show that the location of catches can vary substantially from year to year. In some years, catches were concentrated close to the Finnmark coast, while in other years whales were caught farther north and east in the Barents Sea. This reflects variation in the distribution of minke whales from year to year, which in turn may be due to changes in prey distribution. Since it is not possible to sample animals throughout the year on an annual basis, a basic assumption will have to be made that consumption patterns do not vary temporally or spatially, until this assumption can be tested.

Simulation of minke whale suitability with special emphasis on herring and capelin – Ulf Lindstrøm
The main objective of this preliminary simulation study is to understand how local and large-scale predator-prey processes are linked, and preferably come up with a "running average" estimate of the functional response.

The model will include a resource simulation model and a minke whale foraging model. The simulation of resource densities is performed by using intrinsic geostatistics, as described before, whereas a dynamic state variable model will be used to simulate the minke whale's foraging behaviour. The resource simulation model and ten resource simulations were presented at this meeting along with a simple random walk model.

Discussion
The Working Group noted that the simulation-based estimation of selection parameters should be a valuable if ambitious approach in this area. Using realistic simulated prey fields, the behaviour of simulated predators can be modified until the resulting simulated diet observations mimic those realised in the field under similar conditions. The resulting functions should be extendable to other areas and prey conditions within the range of the simulation testing.

It was noted however that there may be a need for greater complexity than that presently incorporated in the model. Suggestions included including a prey depletion function, such that predators deserted the food patch once density fell beyond a threshold level; inclusion of 3 dimensional foraging; modification of searching behaviour upon encountering a patch; incorporation of state variables such as stomach fullness; and incorporation of temporal change in the prey field. While this will introduce further complexity into the model the results should more realistically mimic observed behaviour.

Modelling diet choice and consumption functions – Tore Schweder
There is a rich economic literature on human choice- and consumer behaviour, and there is a wealth of experience in estimating models on both the individual level and on the aggregated level. The economic paradigm of rationality is that humans make their choices on the basis of utility maximisation within the options available in the situation, and under budget constraints. A weak form of this paradigm might also be appealing to the biologist when modelling animal behaviour on the micro level. One might therefore think that the economic and econometric literature on choice- and consumer behaviour provides guidance when

predation, diet choice and foraging is to be modelled for fish and marine mammals (and also terrestrial species).

Ben-Akiva and Lerman (1985) give an introduction to the theory of discrete choice behaviour. To fix ideas, consider the following constructed adaption of this theory. A minke whale might feed on krill, herring, capelin, gadoids or other food. In this situation, it faces a choice set of 5 alternatives. Each food item is characterised by an (observable) attribute vector x, say of calorie density, local abundance and patchiness. Each choice alternative is associated with a potential utility to the whale. This alternative-specific utility is modelled as v(x)+r, where r is a random component covering unobservable individual taste variation and other sources of random variation, and v transforms the vector of attributes to a scalar utility. The theory is then that the minke whale chooses that food item within the choice set that maximises the individual whale's utility. A popular specification is that the random components are independent over alternatives, and follow a Gumbel distribution. In this case, the probability that the whale chooses a particular food item follows the multinomial logit distribution. A consequence is that the popular axiom of independence of irrelevant alternatives (IIA) is satisfied. This means that, everything else equal, the conditional probability P(capelin | herring or capelin) is the same whether krill, or gadoids are open options – and correspondingly, any other conditional choice probability is fixed regardless of which other options that are available.

In a further development, Dagsvik and Strøm (MS 2002) draw on the psychophysical literature, and find theoretical support for specific functional forms for the function v transforming attributes to utilities. The logarithmic transform is a possible function. It leads to multinomial logistic choice models for which the logits are linear in log prey fattiness, log prey density, log prey patchiness etc.

The example with minke whale diet choice is meant to illustrate that this economic theory might have something to offer, rather than a solution to the very difficult problem of estimating diet choice and selectivity functions in minke whales.

Discussion

It was questioned whether the IIA assumption would indeed hold true for marine mammals. In a case where there are two prey items for which selectivity is the same, the relative selectivity for each will be lower if both are present because the predator will not distinguish between them. In response Schweder pointed out that with the same selectivity the two items would be considered to be the same under this scheme, and that classification of prey items would not necessarily be by species. Two or more species could be grouped together if they are not distinguished by the predator.

There was some discussion over whether baleen whales in particular actually do select prey, or whether the observed apparent selection might be the result of applying 2 dimensional dynamics to a 3 dimensional distribution of predators and prey. Also, the range at which prey items can be distinguished might be quite short, which would make selection unlikely. However it was noted that the observed positive selectivity of minke whales for capelin was in some cases so extreme that it could not be a result of depth distribution, since the depth distribution of capelin and herring was similar. Also, the selection may not occur at a distance, but prey might be ingested and then rejected.

8. RECOMMENDED MODELLING APPROACH FOR NAMMCO

In reviewing the amount of multi-species modelling work and associated applications to management decisions that had been conducted world-wide over the past several years, the Working Group noted a much lower than expected activity in this area. This was considered surprising given the emphasis politicians and management authorities have placed on multi-species (ecosystem) approaches to the management of marine resources. While the principle of multi-species management seems to be widely accepted, the practical

aspects of putting it into practice lag far behind the rhetoric. The Working Group emphasised that progress in this area will not be made unless significant additional resources are dedicated to it.

The Working Group identified the following desirable general features of a modelling approach that would be applicable to analysing marine mammal – fisheries interactions in the candidate areas of the North Atlantic:

- Flexibility of functions for prey selection that can be manipulated by the modeller;
- Flexibility of age structuring, from fully age structured to fully aggregated;
- Accessible source code and transparency of operation- the model must not be a "black box";
- Able to be tailored to the area and species of interest, rather than generic;
- Model interactions accounting for most of the natural mortality of the fish species of concern;
- Spatial and temporal resolution tailored to the target species, with flexibility for changing resolution.
- Uncertainty in data and model structure is reflected in the results.

Considering the data available or likely to become available in the foreseeable future, the Working Group favoured the approach of using a limited model that encompassed only the major species of interest, as opposed to an all-encompassing model where all or most species are included, as a basis for potential management advice in the short to medium term. This approach can be described as a Minimum Realistic-type model, as exemplified by Scenario Barents Sea, MULTSPEC and BORMICON. It was considered that the data demands of a more comprehensive model would be so great for the model to be sufficiently realistic and estimable that there was little likelihood of them ever being satisfied. This would necessitate more guesswork in the specification of such a model. Other components of the ecosystem that are not explicitly modelled, such as primary production or zooplankton, could be left as constant, allowed to vary randomly or linked to environmental covariates. While the output of such a model could not be expected to predict all aspects of future states of the ecosystem, they will be useful for testing management scenarios where the abundances of target species are manipulated.

Some members voiced the concern that the development of ecosystem models without sufficient data in some components would produce results that might be used by inappropriately by managers, who might not understand the level of uncertainty in the results even if it is specified. It was suggested that it would be better to wait until the required data is gathered before proceeding to ecosystem modelling. Other members noted that even models in which some components are parameterised with "plausible ranges" can be useful in determining the sensitivity of the model to variation in parameters, and thus in determining the most important gaps in knowledge. It was agreed that the two activities should proceed simultaneously: that is, the data gaps identified in previous workshops should be filled by dedicated studies, while modelling can proceed in candidate areas, even with partial data, as long as the uncertainty of the results is emphasised and integrated in the results. In this way, modelling approaches can be refined and the reliability of the results will improve as more data is gathered.

There was agreement that the continued development of the Scenario Barents Sea model should be a priority, with emphasis on incorporating the predation of harp seals in the model. The model would be improved by including harp seals and possibly minke whales as endogenous in the model in the sense that their life history parameters would be affected by variation in food supply. However this would be subject to considerable uncertainty given the current lack of information on these effects. The Working Group also recommended that this model be transferred to the GADGET platform after the current round of development has been completed. This will facilitate interface with present single species assessment models, and enhance the transparency of the model and the possibilities for future development. It was noted that such a transfer will require additional resources that are not currently available.

In addition to the above the Working Group recommended the development of a second, more general North Atlantic "template" model based on the GADGET platform. This spatially homogeneous model would

include species important in candidate applications to West and East Greenland, Iceland and the Barents and North Seas. However the abundance of these species would be varied between the areas according to available information. The quality of the available input data varies greatly between areas, and in cases where little information is available, plausible ranges would be used. It will be crucial to capture the full range of uncertainty in these ranges.

In areas where data is lacking, such as West Greenland, the main use of such a model will be to identify the sensitivities to variation in input parameters, and thus to assist in the setting of priorities for research. In Icelandic waters, where better data is available for fish but data on marine mammal diets and prey selection are scarce, such a model will serve the same purpose but also generate preliminary scenario results for management. For the relatively data-rich Barents Sea area, the model will augment the main Scenario Barents Sea modelling effort.

The Working Group recommended the establishment of a planning group to develop the specifications of the template model, should the project proceed. It was emphasised however that the development of such a model is not presently planned or budgeted, and will require additional resources to proceed.

To summarise, the Working Group settled on a two-pronged approach to modelling marine mammal – fisheries interactions in the candidate areas. The first approach will be the further development of the Scenario Barents Sea model, which is already proceeding but could be enhanced with additional funding. The second suggested approach is the development of a more generic, North Atlantic-wide template model based on the GADGET platform, including major fish and marine mammal species of interest from all the candidate areas. The model should be applied to areas that best suit the distribution of the candidate species, as well as available fisheries and marine mammal datasets. The model will initially serve mainly as a mode for sensitivity testing to determine the most profitable avenues for research. As more data becomes available, this model could be further developed into Minimal Realistic-type models for the candidate areas.

9. FUTURE WORK

i. Collection of input data

The Working Group reiterated the priorities for future research identified by the Scientific Committee of NAMMCO in 2001 with regard to refining the estimates of the consumption of marine mammals in the North Atlantic (NAMMCO 2002).

The functional nature of prey selection by marine mammals under varying levels of prey abundance and from mixtures of available prey was considered a further priority for further research. To derive these functions diet data must be collected in conjunction with resource surveys at appropriate temporal and spatial scales.

Migration by fish and marine mammals was considered to be one of the most important factors in modelling their interactions. A great deal of data is available for many of the major fish species, which could be analysed to develop migration models. For marine mammals, there is very little data and much more research is needed, possibly through continued satellite tagging studies.

Data warehouse

It was considered that the Data Warehouse facility offered by the GADGET platform would be an ideal platform for compiling data for future modelling efforts. The use of this facility was strongly encouraged.

Testbed

At present GADGET lacks the scenario aspect where the management process itself is modelled in prognostic simulations. Only when this option is available will it be possible to use an implement the

Scenario mode for its original purpose: to compare management strategies and their related assessment machinery. Developments in this direction should be encouraged.

ii. Linkage to economic models

It was considered that discussion of the economic aspects of marine mammal-fisheries interactions would be premature until these interactions have been initially described and quantified. Once models are available that can predict the variation in target species in response to management measures, linkages to simple economic models that assess the economic consequences of the responses can be made. However it was cautioned that more complex economic models integrating the economic behaviour of fishers and markets under different conditions of resource abundance are themselves subject to great uncertainty and a subject outside the scope of the present Working Group.

10. RESEARCH NEEDS

The Working Group reiterated the research priorities identified by the NAMMCO Scientific Committee in 2001 (NAMMCO 2002). In particular the Working Group emphasised that additional information on harp seal diet and consumption in the Barents Sea is a priority to further the modelling work. In addition the Working Group identified the following priorities:

Prey selection

- theoretical and practical work on prey selection models
- development aggregated consumption functions
- migratory and spatial aspects of consumption models

Multi-species modelling

- Further work on the Scenario Barents Sea model
- Use GADGET as a framework to generate template models for candidate areas in the North Atlantic

11. ADOPTION OF REPORT

The report was approved at 18:40 on 15 September.

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Appendix 2

AGENDA

1. Opening remarks
2. Adoption of Agenda
3. Appointment of Rapporteur
4. Review of available documents
5. Progress after the 2001 NAMMCO Workshop
6. Introduction to multi-species models
    i. Minimum Realistic models- Doug Butterworth
    ii. MULTSPEC- Sigurd Tjelmeland
    iii. Scenario Barents Sea- Tore Schweder
    iv. BORMICON/GADGET- Gunnar Steffansson
    v. ECOPATH/ECOSIM
7. Prey selection processes
8. Recommended modelling approach for NAMMCO
9. Future work
    i. Collection of input data
    ii. Linkage to economic models
10. Research needs
11. Adoption of report

Appendix 3

LIST OF DOCUMENTS

	Title
SC/10/EC/1	List of Participants
SC/10/EC/2	Agenda
SC/10/EC/3	List of Documents
SC/10/EC/4	Schweder, T. Scenario Barents Sea: Issues, approach, model, methodology. (Presentation slides)
SC/10/EC/5	Stefansson, G. DST^2 (Presentation slides)
SC/10/EC/6	Linstrøm, U., Harbitz, A. and Haug, T. Small-scale studies of minke whales (*Balaenoptera acutorostrata*) foraging behaviour in the southern Barents Sea, with particular reference to predation on capelin (*Mallotus villosus*).
SC/10/EC/7	Harbitz, A. and Lindstrøm, U. 2001. Stochastic spatial analysis of marine resources with application to minke whales (*Balaenoptera acutorostrata*) foragine: A synoptic case study from the southern Barents Sea. *Sarsia* 86:485-501.
SC/10/EC/8	Lindstrøm, U. and Haug, T. 2001. Feeding strategy and prey selectivity in common minke whales (*Balaenoptera acutorostrata*) foraging in the southern Barents Sea during early summer. *J. Cetacean Res. Manage.* 3:239-249.

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