REPORT OF THE SIXTH MEETING OF THE SCIENTIFIC COMMITTEE
Reykjavik, Iceland, 1-5 March 1998

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The Scientific Committee of NAMMCO met at the Marine Research Institute, Reykjavik, Iceland, from 1-5 March 1998. The meeting was attended by members of the Scientific Committee and a number of invited experts attended the Scientific Committee Working Group on Economic aspects of marine mammal – fisheries interactions. A full list of participants is contained in Appendix 1.

1-3. OPENING PROCEDURES

The Chairman, Mads Peter Heide-Jørgensen, welcomed members to Reykjavik and to the meeting. On behalf of the Committee, he welcomed in particular the new member of the Committee, Lars Witting, who replaced Pia Barner Neve as member for Greenland this year, and Sidsel Grønvik, the new Scientific Secretary in the NAMMCO Secretariat

The Agenda, as contained in Appendix 2, was adopted and Sidsel Grønvik was appointed as rapporteur.

4. REVIEW OF AVAILABLE DOCUMENTS

4.1 National Progress Reports

National Progress Reports for 1997 from the Faroes, Iceland and Norway, and for 1996 from Greenland (SC/6/NPR - F,G,I & N) were submitted to the Committee.

4.2 Working Group reports & other documents

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

5. COOPERATION WITH OTHER ORGANISATIONS

5.1 ICES

It was noted that ICES had now provided its advice to NAMMCO on the request for an assessment of harp and hooded seals. This was based on the work of the Joint ICES/NAFO Working Group on Harp and Hooded Seals, which had met in Copenhagen 28 August – 3 September 1997 (see under item 8.1 – 8.2), and was circulated to the Scientific Committee for information (NAMMCO/8/8).

The Secretary informed the Committee that negotiations were continuing with ICES to develop a formal Memorandum of Understanding between NAMMCO and ICES.

Tore Haug informed the Committee about the new structure of ICES. Two new formal Working Groups had been established under the Living Resources Committee, the Working Group on Marine Mammal Population Dynamics and Trophic Interactions (WGMMPD) and the Working Group on Marine Mammal Habitats (WGMMHA) both of which were expected to be dealing with questions relevant to the work of NAMMCO. Several of the Committee members were also members of these ICES Working Groups, and the Committee agreed that an exchange of observers between the Scientific Committee and the ICES Working Groups would enhance the information flow on the relevant work being carried out.

5.4 ASCOBANS

The Council of NAMMCO has an agreement with ASCOBANS to exchange observers at a Council level, and reports are regularly exchanged between Secretariats. The Secretariat had received an observer's report from the Second Conference of the Parties, held in Bonn in November 1997, at which Arne Bjørge (Norway) had acted as observer for NAMMCO.

5.5 Canada/Greenland Joint Commission on the Conservation and Management of Narwhal & Beluga

The Secretary informed the Committee that reports were being exchanged on a regular basis with the Canada/Greenland Joint Commission on the Conservation and Management of Narwhal and Beluga, and that she had participated as observer at the Sixth meeting of the Commission, held in Iqaluit, Canada, 28 November to 1 December 1997. The report from that meeting as well as the report of the June 1997 meeting of the Scientific Working Group had been circulated to Committee members.

5.6 International Whaling Commission (IWC)

The Secretary noted that the IWC Scientific Committee at its 1997 meeting had agreed that Nils Øien should attend the NAMMCO Scientific Committee as observer on behalf of the IWC Scientific Committee. It was noted in this connection that the Scientific Committee has no arrangement with the IWC for an exchange of observers on a scientific level. In discussion it was agreed that, given the scientific issues of common interest, it would be valuable in the future to exchange information through observers on a scientific level. Nils Øien agreed to act as NAMMCO Scientific Committee observer in the IWC Scientific Committee.

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

At its last meeting the Scientific Committee agreed that the List of Priority Species should be replaced by a new document - Status of Marine Mammals in the North Atlantic - covering all marine mammal species.

The further development of this document was discussed by the Committee. Sidsel Grønvik reported that due to other recent work priorities in the Secretariat, little progress had been made with the editing of the new document since last year, but that this would be given priority in 1998. A draft text for the section on pilot whales was distributed for information, also as an indication of the major topics which should be included for each species in the document.

The Committee agreed that the information contained in the Status document should be presented in a concise, summary form for the easy reference of the Council, and should contain catch statistics from the last ten years and the recommendations for future research made by the Scientific Committee. Committee members would review the text of the document as it was developed by the Secretariat.

7. ROLE OF MARINE MAMMALS IN THE MARINE ECOSYSTEM

7.1 Economic aspects of marine mammal – fisheries interactions

The Chairman referred to the request from the Council to the Scientific Committee that special attention should be paid to studies related to competition and the economic aspects of marine mammal - fisheries interactions (NAMMCO Annual Report 1997).

To address this request, the Scientific Committee had agreed to establish a Working Group, under the chairmanship of Gunnar Stefánsson (Marine Research Institute, Iceland). The Working Group met from 1-2 March in Reykjavik at the Marine Research Institute, with the participation of, and contributions by members of the Committee and invited experts from Canada, Iceland and Norway. Stefánsson presented the report of the Working Group to the Committee, which was circulated as SC/6/5. The final report of the Working Group is contained in Annex 1.

Bioeconomic multispecies models for various areas and complexes in the North Atlantic were considered by the Working Group. It was noted that such analyses need to include not only profits from whaling or costs due to predation but an entire economic analysis of consequences of management actions on various industries. The models ranged from those with complicated biological components and simple economic parts through simple biological models with more sophisticated economic parts to intermediate models at both levels.

It was noted that most of the analyses considered by the Working Group were of a preliminary nature. The indications are, however, that the overall costs to the fishing, whaling and sealing industries incurred by not whaling and/or not sealing can be quite considerable and the effects due to predation can be an important part of the overall picture.

The analyses to date have not included potential costs of whaling and sealing to industries such as tourism and whale watching nor potential benefits of whaling and sealing to the fishing industry due to a possible change in the frequency of parasites in fish. Some biological factors such as the effects of hooded seals are not at present included. These factors may be important and should be considered.

The Working Group concluded that many of the analyses were in a preliminary stage and should only be taken as first indications. It is clear, however, that some of the cost and benefit figures emerging from these models are quite high and warrant serious consideration.

The Scientific Committee agreed that other species need to be included and that the models presented were not readily applicable to areas like Greenland and the Faroe Islands. However, despite the complexity of the analyses involved, it was the view of the Scientific Committee that inclusion of economic considerations is a valuable addition to multispecies models of interactions between marine mammals and fisheries. The work presented at the Working Group was considered the first step towards more complete analyses of these interactions and it was recommended, in light of the economic impacts, that more complete models should be developed and presented. The Scientific Committee showed a continued interest in the development of the models and it was decided to maintain the Working Group and seek further guidance from the Council on matters of particular interest.

7.2 Other matters

It was noted that the Council encouraged scientific work that leads to a better understanding of interactions between marine mammals and commercially exploited marine resources, and had recommended at its last meeting in 1997 that the Scientific Committee periodically review and update available knowledge in the field.

New information on the changes in biological parameters due to environmental changes was made available from the ICES/NAFO Working Group on harp and hooded seals. Harp seals, sampled in coastal areas of northern Norway during a seal invasion in 1995, were in significantly poorer condition than comparable age groups of harp seals sampled in corresponding seasons in 1992 and 1993. This suggests that the seals may have experienced a food shortage during the winter 1994/1995. When capelin is abundant along the Murman and Finnmark coasts in late winter, it is an important prey for harp seals. The collapse of the Barents Sea capelin stock in 1992/1993 resulted in a reduced abundance of capelin in Norwegian coastal waters and a decrease in the importance of this species as prey for the harp seals. This decline in importance is supported by the dominance of codfishes in the diet in 1995 which was also observed during the major seal invasions in 1986–1988. A decreased abundance of immature herring in the southern Barents Sea during 1994 and 1995 may also have contributed to the seal invasions that winter. Harp seals are known to also feed on polar cod during late autumn and winter. The stock size of polar cod in the Barents Sea has increased and was estimated at nearly one million tons in 1992 and 1993. This may have been one of the reasons why the harp seal invasions in 1995 included only immature animals.

Variations in the inflow of warm Atlantic water into the Barents Sea can influence the distribution and abundance of fish species in this region. Low water temperatures may lead to changes in the distribution and availability of important prey species for the harp seals and may cause them to move into the western parts of the Barents Sea.

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

8.1 Harp seals

Based on a request forwarded by NAMMCO in May 1995, a meeting in the Joint ICES/NAFO Working Group on Harp and Hooded Seals was convened at the ICES Headquarters in Copenhagen, Denmark from 28 August to 3 September 1997. The intention of the meeting was to provide assessment advice on harp seals in the White Sea and Barents Sea, and harp and hooded seals in the Greenland Sea. The terms of references formulated by Advisory Committee on Fisheries Management (ACFM) in response to this request and questions that arose from the 1993 meeting of the Working Group, were as follows:

a) assess the stock size, distributions and pup production of White Sea / Barents Sea harp seals and harp and hooded seals in the Greenland Sea;

b) subject to the availability of data, assess the sustainable yield at present stock sizes and provide catch options in the Barents and White Seas and in the Greenland Sea;

c) review existing population models for harp seals in order to standardise the methodology used to estimate the numbers at age;

d) assess current information on the effect of recent environmental changes or changes in the food supply on harp and hooded seals, and review available data on the possible interaction between these seal species and other living marine resources.

Stock Identity, Distribution and Migrations

Results of a study on the stock identity of harp seals using DNA analysis support previous analyses that indicate a separation between the western and eastern Atlantic groups.

Results from satellite tracking experiments were available both from the Northwest Atlantic and from the Barents Sea. Adult harp seals moulting in the Newfoundland area ranged from the northern Scotian Shelf and Grand Banks of Newfoundland in the spring and winter, north to Baffin Bay, south-eastern Greenland and Hudson Strait in the summer. Offshore waters of the Grand Banks and Davis Strait appeared to be important feeding areas during the winter and summer, respectively. The occurrence of seals on the southern Grand Banks, Flemish Cap and Scotian Shelf may indicate a southern shift in distribution in recent years.

Results of joint Norwegian/Russian telemetric studies in the White Sea showed feeding migrations out of the White Sea and westwards in the Barents Sea of adult females in the period between breeding and moult. Another group of adult harp seals were equipped with satellite-tags after moulting in the White Sea in early May 1996. The results confirm the general migration pattern of Barents Sea harp seals described in earlier studies. The seals migrated northwest into the Barents Sea after moult. In July and August they dispersed along the southern edge of the pack-ice belt from 5°W in the Norwegian Sea to 87°E in the north-eastern Kara Sea, occasionally as far north as 82°N. While the seals spent much of their time in close association with the pack-ice, frequent foraging trips were made into open waters of the Barents Sea. In late autumn and early winter the seals moved south gradually with the expanding ice cover.

<u>The Greenland Sea stock</u>

Only Norway took catches of harp seals in the Greenland Sea pack-ice in 1996 and 1997, the total catches being 6,427 and 2,161 animals in 1996 and 1997, respectively. In 1996 half the quota, and in 1997 all the quota could be taken as weaned pups, one adult considered equal to two pups. The catches were well below the quota of 13,100 adults. Between 1990–1997 less than 60% of the quota was taken.

Updates of pup production estimates over the period 1977–1991 indicate an estimate of pup production in 1991 of 67,300 (95% C.I. 56,400–78,113). This is similar to the update presented in 1995, and is about 10% higher than the mean estimate used in the assessment carried out in 1993. No major event that could adversely affect the West Ice harp seal stock since the 1993 assessment could be identified. Since the new estimate of pup production falls within the range investigated at the 1993 meeting, no new catch options were calculated.

The White Sea and Barents Sea stock

Combined Russian and Norwegian catches of harp seals in the White and Barents Sea in 1995, 1996 and 1997 totalled 36,486, 41,049 and 36,399, respectively, i.e. at a level comparable to the catch during the years 1989 to 1994. The proportion of pups taken ranged between 81–86%.

A Russian aerial survey of harp seal pups in the White Sea was performed on 12 March 1997. Three methods yielded estimates of pup production, uncorrected for the distribution of births over time, of 68,700 ± 10,800 from a photographic survey, 76,300 ± 19,900 from a video survey and 89,300 ± 23,400 from an IR (infrared) survey. Adding the number of pups taken in commercial catches before the survey (31,319), point estimates from the three survey types ranged between 100,000 and 120,000 pups.

Another Russian aerial survey using strip transect methods was conducted on the whelping grounds in the White Sea from 17–20 March 1997. An estimate of 64,698 (95% C.I.: 61,862–67,533) was obtained. Due to rapid changes in the configuration of ice and pup distribution, the areas surveyed constituted only 41% of the total whelping area. Using an isoline method (adapted from fisheries research), an estimate of 161,442 (95% C.I.: 150,425–172,459) pups was obtained for the entire whelping grounds. Adding the quantity of pups taken by Russian sealers in the White Sea prior to the surveys in 1997 (31,319 whitecoats), point estimates of c.96,000 pups in the strip transect surveys, and c.193,000 pups using the isoline method, would be obtained. Results in selected areas where both methods could be applied, were similar. The appropriateness of using the isoline method to estimate pup production in areas not covered by the strip transect surveys could not be evaluated because additional information on estimation of densities was required. Thus it was concluded that the estimates obtained in the strip transect surveys were minimum estimates, and that the extent of underestimation was unknown.

The strip transect estimates given from the 17-20 March surveys were similar to the estimates obtained in the 12 March survey. Due to the timing of the surveys some pups would have reached the ragged jacket stage by the time of the surveys. Pups at this stage are known to leave the ice occasionally to pursue prey, and therefore may not be counted. Thus, all given estimates are likely underestimates, and the pup production for the White Sea and Barents Sea stock of harp seals was probably at least 100,000 in 1997. Given a pup production of 100,000, an annual take of 40,000 may not be sustainable.

No catch options were provided and this awaits completion of the assessment.

The Northwest Atlantic stock

The Canadian commercial harp seal hunt has increased during the last two years; in 1996 the catch was 242,362 and in 1997 it was 261,043. These are approximately four times the average taken over the last ten years. There has also been a change in the age structure of the hunt with a significant increase in the proportion of pups taken (76% and 84% respectively).

After a period without catch figures for seals in Greenland (1988–92), a new system for collecting harvest data was introduced in October 1992. Catches of harp seals reported through this system for the years 1993–95 (53,642, 54,996 and 60,743, respectively) were significantly higher than the estimated catches in previous years. An examination of the official catch statistics for 1954 to 1987 suggests, however, that the figures reported previously for the period 1975–87 underestimated the true harvest level considerably.

Recaptures of tagged animals have demonstrated that harp seals from all breeding stocks do contribute to catches in Greenland, but it was agreed that when incorporating Greenland catches in population models, all harp seals taken in West Greenland should be considered as deriving from the Northwest Atlantic stock, harp seals taken in Northeast Greenland from the Greenland Sea stock, and harp seals taken in Southeast Greenland should be split equally between the two.

Combining the Canadian and Greenland estimated catches suggests that the current catches are in the order of 300,000. Considering the estimates of replacement yields it was noted that the recent catches of harp seals in the Northwest Atlantic are near, or at, the established replacement levels.

8.2 Hooded seals

The request for advice on hooded seals forwarded to ICES in May 1995 is given in the preamble to section 8.1.

Stock Identity, Distribution and Migrations
A Norwegian study on the seasonal distribution of hooded seals in the Greenland Sea, where nineteen animals were tagged with satellite transmitters, has revealed that the seals remained within the Greenland and Norwegian Sea for the majority of the year. Between July 1992 and March 1993, two of the seals remained near the coast of Northeast Greenland while eight travelled to waters off the Faroe Islands, three to the continental shelf break south of Bear Island, and three to the Irminger Sea. Several seals spent extended periods at sea west of the British Isles, or in the Norwegian Sea between the breeding and moulting periods.

The Greenland Sea stock
Only Norway took catches of hooded seals in the Greenland Sea in 1996 and 1997, the total amount being 811 and 2,934, respectively. In 1996 half the quota, and in 1997 all the quota, was allowed to be taken as weaned pups, one adult equal to two pups. The catches were well below the quota (9,000 adults). Between 1990–1997 about 25% of the quota has been taken.

In March 1997 a Norwegian survey found the largest patch of breeding hoods to the northeast of Jan Mayen, while a number of small patches, family groups, and solitary bluebacks were recorded to the northeast, west, and northwest. Six whelping patches were covered by photography, and the total point estimate for these was 25,300 pups (95% C.I. 18,200 to 35,100). For the main patch, visual surveys were also carried out, and they seemed to be in agreement with the photographic surveys. The estimate of 25,300 hooded seal pups produced in 1997 is not corrected for the temporal distribution of births or for scattered pups.

No catch options were provided and this awaits completion of the assessment.

The Northwest Atlantic stock
The most recent information on the catch of hooded seals in Greenland was compared with information gathered during the previous forty years. The figures for the catch of hooded seals in Greenland in 1993 and 1994 (6,906 and 7,330 respectively) are slightly higher than those estimated for the 1980s, but in line with the trend shown since the early 1950s. For most regions the present catch level is within the range estimated for previous decades, but in southwest Greenland the level is higher. Catches of hooded seals during the 1980s were likely underestimated, but revised estimates are not available.

In 1996, a total of 25,754 hooded seals were taken in Canadian waters, which is more than three times the allowable quota. The majority of these were bluebacks taken prior to 28 March. Reasons for this large catch included favourable ice conditions and good prices for the blueback pelt. In 1997, the total number of hooded seals taken was 7,058, just under the allowable quota of 8,000. In contrast to the previous year, the catch was reported to be adults.

The total catch of hooded seals in the Northwest Atlantic in 1996 slightly exceeded the replacement yield while in 1997 the total number of seals taken was much lower.

The Davis Strait hooded seal whelping patch was located by survey aircraft on 17, 21 and 22 March 1997. The seals were first sighted at approximately 63°36'N 57°30'W along the edge of the pack ice; by March 21, they had drifted to the northwest (64°00'N 59°00'W). Although the area could not be searched extensively, there appeared to be only one concentration of seals in the region.

8.3 Ringed seals

In 1996 the Scientific Committee was asked to give advice on ringed seals *(Phoca hispida)*:

"… to advise on stock identity for management purposes and to assess abundance in each stock area, long-term effects on stocks by present removals in each stock area, effects of recent environmental changes (i.e. disturbance, pollution) and changes in the food supply, and interactions with other marine living resources."

An *ad hoc* working group estimated total abundance in Baffin Bay and associated waters, by extrapolating published survey data to not surveyed areas with the same ice conditions. By these means a crude estimate of 1.3 million ringed seals was found for this area. The annual harvest in the order of 100,000 is therefore 7-8 % of the estimated abundance or close to published estimates of sustainable yield (see *NAMMCO Annual Report 1996*: 137-153).

Another calculation found that the annual kill by polar bears (140-170,000) and other predators (20% of what is taken by polar bears) together with the harvest (100,000) would need a standing population after pupping of 1.1 to 1.6 million ringed seals.

These rough estimates were included in the advice, but the main reasons for assuming a sustainable harvest from the Baffin Bay population were: a) that the present harvest level have been maintained for more than a century; b) that the harvest has a high proportion of males and young seals; and c) that the very wide and uniform distribution of the ringed seals buffers the species against wide-scale over-exploitation.

The harvest on the east coast of Greenland was found to be small and likely to be taken from a wide geographical area producing large numbers of ringed seals, so the removals did not raise concern for the status of the population.

In 1997 the Scientific Committee was asked "… to advise on what scientific studies need to be completed in order to evaluate the effects of changed levels of removals of ringed seals in west and east Greenland."

First, it was noted that the exploitation level of ringed seals in Greenland has shown considerable variability over decades in this century. No effects on seal stocks of changed exploitation levels have been reported. This variability in exploitation is usually ascribed to climatic changes or changes in prices of products or hunting patterns. Therefore, when considering 'changed levels of exploitation' the Scientific Committee chose to focus on scenarios where exploitation is raised by more than twice the level reported in recent years.

It is furthermore assumed that the present hunting patterns with many hunters widely dispersed in Greenland, operating from dinghies or dog sledges, are maintained; i.e. essentially the hunting is restricted to coastal areas.

When reviewing the information about ringed seals and their exploitation in the North Atlantic in 1996 the Scientific Committee identified two major gaps in knowledge:

i) Monitoring of catches as well as studies of loss rates in different types of hunts, the extent of under-reporting, and changes in hunting effort and trade in seal products, should be undertaken in both Greenland and Canada;
ii) Studies are required on the stock identity, productivity and abundance of pack-ice ringed seals, as these seals are believed to help sustain the catches in some areas and may be vulnerable to various human activities other than hunting which occur in the pack ice.

While reiterating its previous recommendations, the Scientific Committee identified the following items of particular importance for addressing the question:

Unexploited segments of the ringed seals populations inhabiting remote and inaccessible areas (e.g. the pack-ice and some fast ice areas in Baffin Bay and the Greenland Sea) are likely a major contributor to the seals that are hunted in coastal areas, but very little is known about the production and dispersal of these seals. Studies dedicated to these apparently unexploited ringed seals should include a variety of techniques; sampling of seals for studies of age structure, reproduction and genetic identity, surveys of birth lairs, tagging and tracking of pups and adult seals for descriptions of movements and dependence of ice habitats.

The proposed studies should lead to a better understanding of the dispersal and mixing of ringed seals from different areas which is critical to the understanding of their contributions to the hunted segments of the population. Having achieved that, it may be necessary to monitor population changes in certain areas of particular importance, such as breeding habitats with many adult seals.

8.4 Harbour porpoises

At its Seventh Meeting in 1997, the Council noted that the harbour porpoise is common to all NAMMCO member countries, and that the extent of current research activities and expertise in member countries and elsewhere across the North Atlantic would provide an excellent basis for undertaking a comprehensive assessment of the species throughout its range. The Council requested the Scientific Committee to perform such an assessment, which might include distribution and abundance, stock identity, biological parameters, ecological interactions, pollutants, removals and sustainability of removals.

The Scientific Committee discussed a proposal for an international workshop/symposium on harbour porpoises, which should involve experts working on this species throughout its North Atlantic range. A preliminary agenda developed by Tore Haug in consultation with a number of other scientists was circulated for discussion. The framework for the agenda derived from the five main topics identified in the request (distribution, abundance and stock identity; biological parameters; ecological interactions; pollutants; removals and sustainability of removals).

The Scientific Committee agreed to entrust Tore Haug with the task of further developing plans for, and convening such a workshop/symposium on harbour porpoise, with the aim of holding it in the latter half of 1999 (e.g. September). In order to ensure the broadest possible participation, the Committee further recommended that invitations should be extended to ICES, ASCOBANS and the IWC. It was envisaged that a summary report from such a workshop/symposium would provide the Scientific Committee with the necessary basis for the requested assessment of this species.

The Secretary advised the Scientific Committee that a more detailed outline of plans for the workshop/symposium should be transmitted to the Council for its approval as soon as possible, in order to ensure adequate time for further planning.

8.5 Central North Atlantic minke whales

In 1997 the Council requested the Scientific Committee to 'undertake an assessment of the status of the Central North Atlantic minke whale stock, including to evaluate the long term effects of past and present removal levels on the stock.'

The Scientific Committee decided to ask the Working Group on Management Procedures to address the request by examining the discreteness of the stock, the past history of exploitation under various assumptions of recent population sizes based on abundance estimates from NASS-87, -89 and -95 and to project a range of removal scenarios.

The Working Group on Management Procedures operated by correspondence and decided to contact relevant expertise to summarise genetic results and to run population trajectories. It was noted that abundance estimates from the recent NASS surveys were already available in a form suitable for the Working Group examinations (see NAMMCO Scientific Committee 1997: Annex 3). To finalise the report to the Scientific Committee, the Working Group met in Copenhagen on 13 and 14 October 1997. The final report from the Working Group is contained in Annex 2.

On the basis of the report from Working Group on Management Procedures, the Scientific Committee reviewed the major conclusions and research requirements related to the assessment of the status of Central North Atlantic minke whales under past and present removals.

i) Discreteness of the stock of minke whales in the North Atlantic

Minke whales in the eastern and western North Atlantic are, at least during summer, separated by the land masses of Greenland and by the deep water of the mid-Atlantic. It thus seems reasonable to assume that on a large scale some segments of the North Atlantic minke whale population are isolated by distance and the topography of the ocean basin. Within the central North Atlantic no hiatus in minke whale distribution could be found between coastal Iceland, East Greenland and Jan Mayen. Tagging studies suggest a small probability of exchange between the Central and Northeast Atlantic, but neither distributional data nor the tagging studies give any resolution for fine scale delineations of minke whales in the North Atlantic.

Genetic studies, including allozymes and nuclear DNA, support a splitting between West Greenland, Central and Northeastern Atlantic minke whales, whereas no distinctions could be made for minke whales within the Northeastern area. Morphometric studies suggest a similar stock structure but the data were not conclusive on whether these stocks can be treated as completely isolated populations, as overlap was considerable.

Studies of mtDNA failed to detect any differences between minke whales from West Greenland, coastal Iceland and the Barents Sea, but this should not be interpreted as proof of an homogenous population structure.

In conclusion, some regional delineations of North Atlantic minke whale stocks can be expected, but the present knowledge about movements, dispersal and genetic exchange is too limited, inconsistent or scattered to support a conceptual model for the dispersal and mixing of minke whales in the North Atlantic. On a finer scale, e.g. within the Central Stock Area, nothing supports a further delineation of the stock, however, available studies suffer from incomplete or biased sampling of the whales in the area or from deployment of inadequate techniques.

ii) Population trajectories

The population model used for projecting past exploitation levels through the recent population estimates from NASS 1987 and 1995 utilised the best available data on biological parameters for North Atlantic minke whales as well as a range of estimates of MSYR, although focusing on values around 2-3%. Population trajectories were run for two options of possible stock structure; one considering the Central stock area as a discrete stock and another considering the coastal waters of Iceland (CIC) as a discrete stock.

For the Central Stock Area the minke whales are now close to their carrying capacity. Present removals and catches of 292 per year (corresponding to a mean of the catches between 1980-84) are sustainable. If catches of 451 whales per year (average for 1965-69) are projected to 2001 and if the lower range of the, albeit conservative, estimate of abundance is used in the projections, the harvesting rate is unsustainable.

Catches in the coastal Icelandic area (CIC) ceased in 1985 and catch projections suggest that the stock is now close to its pre-exploitation size. All projections to 2001 of 185 whales per year (average for 1961-85) are sustainable under parameter values considered appropriate.

iii) Future research

There is evidently a great need to resolve the question of stock delineations of minke whales in the North Atlantic. No single or simple method alone seems to be able to answer these questions, and it is recommended that a variety of approaches should be attempted. However, it was also strongly felt that the studies deployed should be focused on testing hypotheses for the year-round mixing and dispersal of minke whales. There is also a need for monitoring of changes in abundance in both coastal Icelandic waters and the entire Central Stock Area, especially if the level of exploitation is increased.

8.6 Narwhal

At its 1997 meeting, the Council recommended that the Scientific Committee should examine the population status of narwhals and belugas in the North Atlantic. Plans for how to proceed with this matter were discussed. Since narwhals and belugas inhabit the same areas, and the development of a status assessment for both species would draw upon the same expertise, it was decided to treat the two species together.

It was decided to establish a Working Group on the Population Status of Narwhals and Belugas in the North Atlantic, and to invite experts from Canada and Russia and other countries to contribute. The Working Group would aim to meet prior to the next meeting of the Scientific Committee in 1999.

8.7 Beluga

See under item 8.6 above.

9. DATA AND ADMINISTRATION

The Committee referred to discussions at its last meeting in 1997 related to the maintenance of a catch database in the Secretariat. A set of guidelines for the submission of catch data had been prepared by the Secretariat last year (NAMMCO/7/6, Appendix 4), the purpose of which was to establish permanent routines for the format and regular submission of catch data from member countries.

The Secretary noted that detailed catch data were not being received on a regular basis from all member countries. Clarification was sought from Scientific Committee members on the availability of more detailed catch data, as distinct from the summary catch statistics included in the National Progress Reports submitted to the Scientific Committee each year.

Some members of the Committee were of the view that it would be better to compile relevant data in response to specific tasks generated by requests from the Council. It was agreed, however, that the question of procedures for the regular submission of data to the Secretariat should be referred to the Council.

10. PUBLICATIONS

The Committee agreed that the title of the new NAMMCO series of scientific publications should be *NAMMCO Scientific Publications*, with volumes numbered.

10.1 Volume 1 - Ringed seals in the North Atlantic

The Chairman who is co-editing the ringed seal volume together with Christian Lydersen of the Norwegian Polar Institute in Tromsø, informed the Committee of progress with the editing. Most of the 13 papers had been received in their final revised versions. It was expected that the publication would be completed by the summer of 1998.

10.2 The role of marine mammals in North Atlantic ecosystems

Gísli Víkingsson who is co-editing the ecology volume together with Finn Kapel informed the Committee of the progress with this publication. It will contain 11 papers, eight of which had been received and sent to reviewers. Garry Stenson, Canada had agreed to write an introductory review paper. It was expected that the volume would be completed in 1999.

10. 3 Other publications

Geneviève Desportes, who is co-editing the volume on sealworm together with Gary McClelland (Canada), reported that she was about to send out the invitations to authors that presented papers at the meeting of the Working Group on Sealworm Infestations. Assuming that a sufficient number of papers would be available for the volume and a production time of 18 months, the volume was scheduled to come out in 1999.

No progress has been made on the planned volume that should present the results from the NASS-95 survey, however, it was indicated that these plans were still under way and that the volume would be expanded to include an in-depth analysis and comparison of all the NASS surveys for all species with sufficient data. Nils Øien, in cooperation with Jóhann Sigurjónsson, was willing to pursue this plan.

In arranging future working groups and the planned workshop/symposium on harbour porpoises, the Scientific Committee noted the importance of ensuring a high standard of presentations in order to allow for possible publication in future volumes of *NAMMCO Scientific Publications*.

11. BUDGET

The Scientific Committee noted that the NAMMCO budget for 1998 included the same level of funding for the Scientific Committee as in previous years (i.e. NOK 435,00 for external expertise and projects). Based on previous experience it is expected that the planned activities in 1999 (see item 12 below) can be carried out within this same level of funding.

12. FUTURE WORK PLANS

12.1 Scientific Committee

Noting that the Scientific Committee has a tradition of rotating its meetings between member countries, it was agreed that next meeting should be held in Nuuk, Greenland, in 1999. It was agreed to aim at having the meeting in late April-early May.

12.2 Working Groups

It was noted that the request for an assessment of the Central North Atlantic Minke Whale stock had been dealt with by the Working Group on Management Procedures and that this work was completed. Future work for this Working Group would await further requests from the Council.

The Working Group on the Economic Aspects of Marine Mammal-Fisheries Interactions had its first meeting in March 1998. In reviewing the report and its conclusions, the Scientific Committee showed a continued interest in the subject and recommended that the Working Group meet again within a year to further develop its advice.

To deal with the request for a population status of narwhals and belugas, a Working Group on the

Population Status of Narwhals and Belugas in the North Atlantic was established, and it was decided that the Scientific Committee Chairman should arrange for this to meet in 1999.

It was agreed that the Working Group on Abundance Estimates should remain in place to deal with the preparation and editing of the NASS surveys to appear as a volume of NAMMCO Scientific Publications.

12.3 Other matters

Preliminary plans for a workshop/symposium on harbour porpoise were discussed (see item 8.4).

13. ANY OTHER BUSINESS

On behalf of the Committee, the Chairman thanked the Marine Research Institute for their hospitality and the excellent facilities they provided, and the Secretariat for their assistance with practical arrangements and report editing.

On behalf of the Committee members, Tore Haug thanked the Chairman for efficiently leading the Committee through its agenda.

14. ADOPTION OF REPORT

The report was adopted on 5 March 1998.

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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
6. Update on Status of Marine Mammals in the North Atlantic
7. Role of marine mammals in the marine ecosystem
    - 7.1 Economic aspects of marine mammal-fisheries interactions
    - 7.2 Other matters
8. Marine mammal stocks -status and advice to the Council
    - 8.1 Harp seals
        - 8.1.1 Update on progress
        - 8.1.2 Future work
    - 8.2 Hooded seals
        - 8.2.1 Update on progress
        - 8.2.2 Future work
    - 8.3 Ringed seals
        - 8.3.1 Update on progress
        - 8.3.2 Future work
    - 8.4 Harbour porpoise
        - 8.4.1 Update on progress
        - 8.4.2 Future work
    - 8.5 Central North Atlantic minke whales
        - 8.5.1 Update on progress
        - 8.5.2 Future work
    - 8.6 Narwhal
    - 8.7 Beluga
9. Data and administration
10. Publications
    - 10.1 The ringed seal volume
    - 10.2 The role of marine mammals in the North Atlantic ecosystem
    - 10.3 Other publications
11. Budget
12. Future work plans
    - 12.1 Scientific Committee
    - 12.2 Working groups
    - 12.3 Other matters
13. Any other business

Appendix 3

LIST OF DOCUMENTS

Committee documents:

SC/6/1	List of Participants
SC/6/2	Agenda
SC/6/3	List of Documents
SC/6/4	Report of the Working Group on Management Procedures, Copenhagen, 13–14 October 1997
SC/6/5	Report of the Working Group on Economic Aspects of Marine Mammal-Fisheries Interactions, Reykjavik, 1 – 3 March 1998
SC/6/6	Report of the Joint ICES/NAFO Working Group on Harp and Hooded Seals (NAFO SCS Doc. 97/17)
SC/6/7	What kind of studies are needed to evaluate changed levels of removals of ringed seal exploitation in Greenland. A proposal for discussion prepared by Aqqalu Rosing-Asvid
SC/6/NPR-F	Faroe Islands - Progress Report on Marine Mammal Research in 1997
SC/6/NPR-G	Greenland - Progress Report on Marine Mammal Research in 1996
SC/6/NPR-I	Iceland - Progress Report on Marine Mammal Research in 1997
SC/6/NPR-N	Norway - Progress Report on Marine Mammal Research in 1997

Council document:

NAMMCO/8/8 Report of the ICES Advisory Committee on Fishery Management on Harp and Hooded Seals (advice from ICES to NAMMCO‘s request).

REPORT OF THE NAMMCO SCIENTIFIC COMMITTEE WORKING GROUP ON THE ECONOMIC ASPECTS OF MARINE MAMMAL - FISHERIES INTERACTIONS

Marine Research Institute, Reykjavik, Iceland, 1-2 March 1998

At its Seventh Meeting in Tórshavn in May 1997, the Council requested that special attention should be paid to studies related to competition and the economic aspects of marine mammal - fisheries interactions.

To address this request, the Scientific Committee agreed to establish a special Working Group, under the chairmanship of Gunnar Stefánsson (Marine Research Institute, Iceland). The Working Group met from 1-2 March in Reykjavik at the Marine Research Institute. Participants are listed in Appendix 1.

1-3. OPENING PROCEDURES

The Chairman of the Working Group, Gunnar Stefánsson, welcomed participants to the meeting. The agenda, as contained in Appendix 2, was adopted. Secretariat staff functioned as rapporteurs and it was agreed that relevant members of the group would also assist with the drafting of relevant sections of the report.

4. HISTORICAL BACKGROUND

The Working Group noted that the hunting of marine mammals has long been a part of the traditional economic use of marine resources across the North Atlantic. Lower levels of marine mammal utilisation in many areas in recent years compared with previous decades, combined with increasing pressure on fish stocks from fisheries, has introduced new factors into discussions related to the management of marine mammals, with an emphasis on the need to better understand the interactions of marine mammals and fish in the marine ecosystem. Such factors include, in particular, concerns in the fisheries sector about the potential effects of growing marine mammal populations on fish stocks. The Working Group further noted that in some sectors there were also concerns related to the possible effects of marine mammal utilisation on other economic activities, such as whale watching operations, although these were not directly related to either fisheries or whaling and sealing activities.

The Working Group agreed that an analysis of the economic aspects of marine mammal-fisheries interactions should encompass all aspects of the situation, including both potential losses in fish resources due to increases in marine mammal populations, as well as the estimated revenues from whaling and sealing weighed against the potential losses in other sectors.

5. MULTISPECIES MODELS FOR MARINE MAMMALS AND FISH

Several multispecies models have been developed to describe interactions between marine mammals and fisheries (NAMMCO Scientific Committee 1997:35-52). MULTSPEC (Bogstad *et al.* 1998) and Bormicon (Stefánsson and Pálsson 1998) are spatially disaggregated models containing a high level of detail. Aggregate models such as AGGMULT (Tjelmeland 1995) and the TSB-model (Flaaten 1988) have been developed for the Barents Sea, and similarly aggregated models have been developed and used for the Icelandic shelf and adjacent areas (Stefánsson et al. 1998; Daníelsson *et al.* 1998). MULTSPEC has been used to describe interactions between several species including marine mammals in the Barents Sea, but only aggregate models have been used for this purpose for Icelandic waters.

The present meeting has these various models as a background and it appears a natural way forward to use some of these with additional economic components.

In addition to these models, alternative economic models are described in section 6, where different underlying biological models are assumed. Such different approaches provide interesting possibilities in terms of comparing overall results.

6. BIOECONOMIC MULTISPECIES MODELLING FOR MARINE MAMMALS AND FISH

6.1 Background

An oral presentation based on Flaaten (1996) discussed some of the advantages and disadvantages of bioeconomic multispecies modelling, as well as the obstacles likely to be encountered in changing from single species to multispecies modelling and management. This was done by use of examples from North Atlantic fisheries, and use of basic bioeconomic theory.

All modelling of economic and biological systems is costly, especially data collection by research vessels. The initial contribution from economists in some cases should be simple cost-benefit analysis of marine research to get a rough idea whether it is likely or not that more complex and detailed models can improve management. However, if a biological multispecies model already exists, it is a good investment to let (resource) economists extend it into a bioeconomic multispecies model.

6.2 Putting a price on predation

Flaaten and Stollery (1996) developed a bioeconomic model to analyse the costs for the harvesters of prey species resulting from a permanent increase in the stock of a natural predator. The theoretical analysis showed that the economic losses depend critically on the type of management of the prey stock, although the measures are equal when the stock is managed at the maximum sustained economic yield from the prey species. The model was applied to the case of the Northeast Atlantic minke whale's consumption of fish. Using fish harvest costs and revenues derived from the Norwegian fisheries directorate, the estimates of average predation cost per minke whale under three different assumptions about whale predation range from US$ 1,780 to US$ 2,370 or NOK 12,500 to NOK 16,600. A ten percent increase in whale stocks was estimated to cause a loss of almost US$ 19 million to the fisheries of the prey species. In discussion, these predation cost estimates were compared with those arising from the much more complex MULTSPEC model of Barents Sea fish and mammal interaction which derived predation costs per whale of NOK 5,600. They were reconciled in that the simpler bioeconomic model assumed predation over a wider area and over both summer and winter.

Paper SC/6/EC/4 extended the model of Flaaten and Stollery, which estimated the direct cost of predation for a fishery exploiting a prey species, to the case of a fishery competing for prey with a mammalian predator. An attempt was made to apply the model to the Northwest Atlantic harp seal predation on capelin in NAFO division 2J3KL, in competition with Atlantic cod, but the estimates of predation costs are very unreliable.

Preliminary results shown in SC/6/EC/8 indicate that predation costs of harp seals in the Barents Sea could be in the range of NOK 150-500 per seal. However, some of the biological and economic data used are rather uncertain and the paper requires more work.

6.3 Economic factors to be taken into consideration

The management of a marine mammal predator should ideally include all relevant economic factors such as:

i) harvest revenues (fur, meat, blubber etc.)
ii) harvest costs (vessel, crew, fuel etc.)
iii) predation costs incurred by prey fisheries due to competition to these fisheries (needs costs and earnings data etc. for the prey fisheries to derive net value per unit prey in the sea)

iv) costs incurred by prey fisheries production due to seal worms etc.
v) the positive effects of fish stocks on growth, reproduction, etc of marine mammals
vi) non-use values:
   -positive: seal/whale watching, existence value, precautionary value etc.
   -negative: predatory killing of non-use valued prey; for example walruses and killer whales killing seals.
   Methods of estimating non-use values exist, but should be used with great care (e.g. travel costs, and survey techniques such as contingent valuation methods and conjoint analysis).
vii) Boycott and trade sanction costs to the fishing industry and other industries of the whaling and sealing nations or regions.

7. THE ECONOMICS OF UNCERTAINTY

Sources of uncertainty in predictions of economic yield range from the obvious uncertainty in recruitment to the various stocks through assessment uncertainty to uncertainty in market and cost aspects of the various predators.

Given some management regimes, a price can be attached to these various sources of uncertainty. For example, if fishing operations are limited so as to ensure that biomass of the fish stock is above Bmsy with e.g. 95% probability, then a high degree of uncertainty will lead to an under-utilisation of the resource. In this case there is a cost associated with uncertainty and this cost can be evaluated in economic terms.

Including marine mammals in multispecies models has been seen not only to reduce the predicted yields from the fish resources but also to increase the degree of apparent uncertainty associated with these yield predictions. The change in economic yield due to the increased uncertainty has not been evaluated in conjunction with these economic models. In part this is due to the fact that it is not obvious at the outset how the uncertainty affects the management regimes. For example, in Icelandic waters the harvest control rule (HCR) for cod is simply to catch 25% of the biomass and for capelin it is to leave 400,000 tonnes for spawning.

In order to evaluate the cost of uncertainty the definition of the harvest control rules needs to be written out more explicitly. For cod in Icelandic waters the HCR was originally taken as “25% of available biomass but no less than 165,000 tonnes”, where the lower bound has not been used after the first year. The reason for this particular choice of lower bound was to ensure a very low probability of further decline in stock size (less than 1% in simulations with fish species only). In this case it is clear that a reduction in uncertainty might have led to a less severe reduction in initial catches. Similarly, if marine mammals are included, then this will lead to greater apparent uncertainty and thus a need for a further reduction given this criterion.

This approach may possibly lead to a method for estimating the cost associated with uncertainty in this particular ecosystem and should be investigated further, since this may eventually provide a relevant price to pay for collecting minke whale stomach content data in order to reduce uncertainty in yield predictions for cod.

8. AVAILABILITY OF RELEVANT COSTS AND EARNINGS DATA

8.1 Cost and earnings data for fisheries

Fisheries cost and earnings data exist at varying levels of detail. For some areas and fishing sectors these data are available down to the level of a vessel. When such data are available it is possible to estimate costs and earnings associated with the fishing operations in a very detailed manner.

In other areas it may be better to use overall estimates of income, such as the first-hand value per kg of fish or marine mammal and then use an overall estimate of current profits from the harvesting operations. This then yields estimates of current costs which can be scaled with respect to (inverse) stock size in forward predictions.

8.2 Costs and earnings data from whaling/sealing operations

In Norway, the average price of minke whale meat obtained in 1997 was 30 NOK/kg, and on average, about 1.5 tonnes of meat was obtained from each whale. The price obtained for blubber was 1.97 NOK/kg in 1997, compared to 0.10 NOK/kg in 1996 and 23.11 NOK/kg in 1995. For harp seals, the average price was 195 NOK for age 0 seals and 120 NOK for age 1 and older seals. This includes the value of skin, meat and blubber, but not of seal penises. The data on harvesting costs for minke whale show that they are much lower than the revenues. For harp seal, data on harvesting costs were not available, but the seal catch has been subsidised in recent years.

Icelandic fisheries and fishing industry organisations are promoting seal hunting by paying 11,550 ISK (155 US$) for adult grey seals and 2,500 ISK for the skins of grey seal pups. There are other opportunities for selling seal products, and current relevant prices are as follows: skin of common seal pups: 2,000-3,000 ISK, depending on quality; seal meat for human consumption –200-250 ISK per kg; salted seal fat for human consumption – 200 ISK per kg.; seal penises - 500 ISK per penis.

8.3 Other relevant cost and earnings

In addition to obvious and tangible economic factors such as fish and marine mammal yields, there are other sources of costs and income which may vary and should be considered. These include whale watching for which economic data may exist. It should in principle be possible to include such an industry in an economic analysis. Somewhat more complex is the non-use value of the resource, i.e. the value placed on not utilising the resource. Such values have been evaluated through surveys, but a better method for obtaining the correct value would be through the utilisation of transferable quotas which could be bought by parties not interested in harvesting the resources.

9. CASE STUDIES

9.1 Combining MULTSPEC with simple economic models

The work presented in SC/6/EC/5 is based on simulation studies using the Institute of Marine Research (Bergen, Norway) multispecies model for the Barents Sea (MULTSPEC) (Bogstad et al. 1998, see also NAMMCO / SC 1997 etc). This model includes the species capelin, cod, herring, harp seal and minke whale. Harp seal, minke whale and cod are all predators on capelin, herring and cod, and herring is a predator on capelin larvae. The growth of cod is dependent on the abundance of herring and capelin, while the growth and reproduction of marine mammals are assumed to be constant.

The results of these simulations are combined with estimates of price and variable harvesting costs for each species valid for Norway. Price elasticities are assumed for cod, capelin and herring, while for harp seal and minke whale, the prices are assumed to be constant. The variable harvesting costs mainly consist of wages and fuel, and the income to the crew is assumed to depend upon the value of the catch. Different cost functions are used for different fleet groups. For harp seal, the harvesting costs are set equal to the price. The total gross and net revenue from the catch of all species is compared for runs with different harvesting strategies for harp seal and minke whale (equilibrium catch or no catch). The initial values of the harp seal and minke whale stocks are 600,000 and 80,000 individuals, respectively. The population model used gives an equilibrium catch amounting to about 33,000 harp seals and 2,500 minke whales, while the population at the end of the 20-year simulation period, assuming no catch, is 1.1 million harp seals and 144,000 minke whales.

The loss in gross revenue resulting from no catch vs. equilibrium catch is approximately the same for harp seals as for minke whales (about NOK 190 million annually). The average annual loss in net revenue resulting from not catching minke whales is, however, considerably larger than the loss resulting from not catching harp seals (62 vs. 27 million NOK annually). When not catching minke whales, 61% of the loss of gross revenue and 79% of the loss of net revenue are due to the direct loss from no whale catch, while the rest of the loss is due to smaller catches of fish. The loss of revenues when not catching harp seals is only due to smaller catches of fish.

The revenues for each country (Norway, Russia, EU, Faroes, Iceland, Others) are also calculated using the present division of catches between countries according to bi- or multilateral agreements. Norway, as the only nation currently hunting minke whales on a commercial basis, suffers most of the loss of gross and net revenues from not catching minke whales, while the loss due to not catching harp seals is divided among the countries approximately proportionally to their share of both gross and net revenue.

9.2 Economic consequences of harvesting regimes for marine mammals in Icelandic waters

Some preliminary results on the effects of different harvesting regimes for marine mammals are given in Fridjónsson (1997) and in SC/6/EC/6. These indicate that the effects of different harvesting strategies for marine mammals can have considerable economic impacts, but these are to a large extent indirect, such as through increased economic yield from other resources (e.g. cod).

It is further noted in Fridjónsson (1997) that there may be a potential adverse effect of a resumption of Icelandic whaling on other industries such as tourism or fish exports such as through possible reductions in prices etc. The Norwegian experience, however, indicates that this is not likely.

The results to date are very preliminary and need to be examined to a much greater extent before firm conclusions can be drawn.

10. CONCLUSIONS

The group agreed that advice on management of marine mammal stocks should take into account as many economic and biological factors as possible. Analyses which only take into account parts of the economical effects, such as only the revenue side or only the profits from whaling, can be highly misleading in the overall picture.

There is a need to continue the current work, and in particular the current biological and economic models need to be refined. Some of the models presented are still in a developmental stage but show promise and should be developed and tested further. Comparative bioeconomic studies of the Northeast and the Northwest Atlantic are encouraged.

The different approaches to bioeconomic modelling should be encouraged in the future as the pursuit of different models provides the opportunity to compare results obtained using very different assumptions. Thus there is little need at the moment for standardisation of models.

It was noted that potentially important species such as hooded seals are at present not included in the models used. These may be important predators and cost factors which should be incorporated in future analyses.

Multispecies bioeconomic models have not been developed for the Faroe or Greenland areas. Such models would need to take into account any special considerations for those areas, possibly including social values placed on the hunting process.

11. ADOPTION OF REPORT

The report was adopted on 3 March 1998.

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1. Chairman's welcome and opening remarks
2. Adoption of Agenda
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SC/6/EC/1	List of participants
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SC/6/EC/4	Ken Stollery: The economic costs of predatory competition. Theory and application to the case of harp seal *(Phoca groenlandica)* predation on fish stocks in the North-West Atlantic
SC/6/EC/5	Bjarte Bogstad: Economic consequences of various harvesting regimes of the marine mammal and fish stocks in the Barents Sea
SC/6/EC/6	Gunnar Stefánsson and Friðrik Már Baldursson: The cost of not exploiting marine mammals.
SC/6/EC/7	Erlingur Hauksson: The Icelandic promotional system for seal-hunting
SC/6/EC/8	Ola Flaaten and Siv Reithe: The predation costs of the Barents Sea harp seal *(Phoca groenlandica)* - some preliminary findings.

ANNEX 2

REPORT OF THE NAMMCO SCIENTIFIC COMMITTEE WORKING GROUP ON MANAGEMENT PROCEDURES

Copenhagen, Denmark, 13 - 14 October 1997

1. OPENING REMARKS AND TERMS OF REFERENCE

The Chairman, N. Øien, welcomed the participants (Appendix 1), and M. P. Heide-Jørgensen explained the practical arrangements for the meeting which was held in the offices of the Greenland Institute of Natural Resources in Copenhagen.

The meeting was arranged to answer a request from the Council to the Scientific Committee, dated 4 March 1997, to provide scientific advice on the following matter prior to the next meeting of the Council: "In the light of the new survey abundance results the Scientific Committee is requested to undertake an assessment of the status of the Central North Atlantic Minke Whale stock, including to evaluate the long term effects of past and present removal levels on the stock."

Preparations for the meeting had been arranged by correspondence and included review of stock structure, biological parameters and abundance estimates of minke whales in the North Atlantic, as well as population modelling.

2. ADOPTION OF AGENDA

The agenda as adopted is given in Appendix 2.

3. APPOINTMENT OF RAPPORTEUR

M.P. Heide-Jørgensen was appointed to assist the Chairman as rapporteur.

4. REVIEW OF AVAILABLE DOCUMENTS AND REPORTS

The Working Group had received several working papers, as listed in Appendix 3, to assist in discussions.

5. THE CENTRAL NORTH ATLANTIC MINKE WHALE STOCK

5.1 Stock structure

North Atlantic minke whales have been divided into four management stocks by the International Whaling Commission (Donovan 1991): (1) the Canadian East coast stock; (2) the West Greenland stock; (3) the Central stock and (4) the Northeastern stock. During the IWC Scientific Committee's development of the Revised Management Procedure these stock areas were considered medium areas and further divided into small areas (IWC 1994). The Central medium area was divided into an East Greenland coastal area (*CG*), a coastal Icelandic area (*CIC*), an area around Jan Mayen (*CM*) and finally the waters south of Iceland (*CIP*). Most of the studies presented on North Atlantic minke whale stock structure refer to these divisions and these are therefore shown in Figure 1.

A. Daníelsdóttir presented her review of the population genetic structure of North Atlantic minke whales (SC/6/MP1). The review describes the results from various nuclear (n) and mitochondrial (mt) DNA methods used to study the genetic relationship of minke whales (*Balaenoptera acutorostrata*) from different geographical locations in the North Atlantic: The West Greenland area, the Central area (Iceland) and the Northeastern Atlantic area. The sampled areas are shown in Figure 2. The results from the studies are discussed and compared with genetic studies of minke whales from other locations. Daníelsdóttir concluded that when nonselective nDNA and/or mtDNA genes show significant differences between sample locations, then it is possible to conclude that there is restricted gene flow between them and they can be managed as separate populations. Concordant and nonconcordant results have been obtained using both nDNA and mtDNA on the same populations and samples in a number of species. It is more common that the mtDNA shows differentiation between populations and that the nDNA does not (e.g. dispersal of males, recent bottlenecks), but less differentiation in mtDNA than nDNA is also found (smaller genome size, founder effects, female biased breeding and/or migration ratio). There is a tendency for the mtDNA to show greater population differences, because of its lower effective population size and effective migration rate (maternal inheritance) which make the effect of genetic drift greater and therefore may lead to greater population differentiation. The gene diversity, however, at equilibrium between mutation and drift, is much lower for mtDNA than nDNA (assuming mutation rates are similar). The different evolutionary dynamics of nDNA and mtDNA can, if combined in a study, provide information on otherwise hidden behaviour and/or population structure. It should be emphasised that it can be misleading to conclude that there are similarities between samples, when the study considered is based on variation at a single gene or locus.

Daníelsdóttir concluded that, based on the genetic evidence available today: 1) Northeastern and Central Atlantic minke whales represent separate populations, and 2) Northeastern Atlantic and West Greenland minke whales represent separate populations.

In the discussions, the importance of comparing the same tissues between investigations when dealing with allozymes was pointed out. Temporal variations due to different sampling periods between areas must also be taken into account, as well as possible heterogeneity related to sex. As suggested in SC/6/MP/4, the analyses done so far have detected indications of certain structures among North Atlantic minke whales, but a satisfactory model which provides a coherent explanation compatible with most of the data has yet to be identified.

From the manager's point of view the basic question would be: How large are migration rates, and how do they affect management goals? Conclusions are also hampered by the fact that no internal comparisons have been made within the Central stock area, or between Jan Mayen and Icelandic coastal waters.

The review of the population genetics revealed an equivocal picture of the structure of the minke whale population in the North Atlantic. Two lines of evidence (allozymes and nuclear DNA) supported a splitting between West Greenland, Central and Northeastern Atlantic, whereas no distinctions could be made for minke whales within the Northeastern Atlantic. Other genetic studies based on mtDNA did not detect heterogeneity between these areas, but this should not be interpreted as proof of an homogenous population structure. Also, different weight should be given to different studies and it was specifically argued that studies based on a relatively limited part of the genome of mtDNA were unsuitable for detecting population delineation. Generally the genetic studies were conducted on a large scale, i.e. trans-Atlantic comparisons, where isolation by distance seems to be a reasonable hypothesis. On a finer scale it seems unlikely that genetic studies can establish management units.

To summarise, the available evidence in support of ***population heterogeneity*** in North Atlantic minke whales is:
- studies of allozymes and nuclear DNA support large-scale segregation in regions;

- mark-recapture analyses of minke whales around Iceland and in the Barents Sea (Northeastern Atlantic) show little chance of exchange of minke whales between these two areas (IWC 1991);
- Morphometric studies suggest that there is substantial heterogeneity between minke whales sampled from West Greenland, Central and Northeastern stocks, but the data were not conclusive on whether these stocks can be treated as completely isolated populations as overlap was considerable (Christensen et al. 1990);
- temporal differences in lengths and sex in some areas suggest segregation in the migrations of minke whales (IWC 1977).

Evidence for ***population homogeneity*** in North Atlantic minke whales is:
- mtDNA studies found no significant differences between widely separated areas such as West Greenland, Icelandic coastal waters and the Barents Sea;
- when the allozyme genotypes were tested for Hardy-Weinberg equilibrium for each of the small areas, no support for heterogeneity within small areas could be detected;
- during the summer minke whales are distributed in a continuum on the continental shelves in the North Atlantic. Only the deep slopes between Iceland and the Faroe Islands, between the Greenland Sea and the Norwegian Sea and south of Greenland, show disjunction in minke whale distributions. No hiatus in distribution is evident between coastal Iceland, East Greenland and Jan Mayen. Thus it seems unlikely that discrete subunits of minke whales persist in this area, considering the long-range migratory abilities of minke whales.

Minke whales in the eastern and western North Atlantic are, at least during summer, separated by the land masses of Greenland and by the deep water of the mid-Atlantic. It thus seems reasonable to assume that on a large scale some segments of the North Atlantic have been isolated because of distance and topography. This is supported by some genetic studies. The tagging studies, albeit biased to hunted whales, indicate philopatry to the Central and Northeast Atlantic with little expected exchange, whereas distributional inference gives no indication of population structure on a finer scale than the Central, Northwest and the Northeast Atlantic.

In conclusion, some heterogeneity of the minke whale population may be expected, but at present the evidence is too limited, inconsistent or scattered to support a conceptual model for the dispersal and mixing of minke whales in the North Atlantic. On a finer scale, e.g. within the Central stock area, nothing supports a further delineation of the stock, however, the available studies suffer from incomplete or biased sampling of the whales in the area or from deployment of inadequate techniques.

Although nothing supports a delineation of minke whales between coastal Icelandic waters, East Greenland and the area between Iceland and Jan Mayen, a safe approach, in the light of inadequate research, would be to maintain the small areas as putative stock units.

5.2 Biological parameters

Víkingsson reviewed the available information on biological parameters (SC/6/MP/3). As part of the International Whaling Commission’s work on the Comprehensive Assessment of minke whale stocks in the North Atlantic, a table of available data on biological parameters was prepared (Larsen 1991). Since then, no new information on the relevant biological parameters of minke whales in the North Atlantic appears to have been published. Víkingsson prepared Tables 5.2.1 and 5.2.2 based on the information given in Larsen (1991) and the parameter values used in the IWC’s assessment in 1990 (IWC 1991). The Working Group decided to base their assessments on these data.

Table 5.2.1. Biological parameters in Central North Atlantic minke whales.

Parameter	**Value**	**Note**	**Small area**	**Reference**
Age at recruitment	5.5 11.5	50% recruited 95% recruited	CIC CIC	IWC 1991 IWC 1991
Age at sexual maturity (females)	6 6-7 5-6	Regression 50% mature Regression	CIC CIC CIC	Sigurjonsson 1988 Sigurjonsson 1988 Sigurjonsson et al. 1990
Sex ratios in catch	43% females 43.4% females		CG CIC	Larsen & Øien 1988 Sigurjonsson et al. 1990
Pregnancy rates	0.94		CIC	Sigurjonsson 1988
Natural mortality rates	0.10 (approx)			Horwood 1990.

Table 5.2.2. Parameter values used in recent assessments of Central North Atlantic minke whales.

Parameter	**% of population**	**Value**	**Year**	**Reference**
Age at recruitment	100 50 50 50 95 95 95	4 5.5 7.5 3 11.5 13.5 6	1988 1990 1990 1990 1990 1990 1990	IWC 1989 IWC 1991 IWC 1991 IWC 1991 IWC 1991 IWC 1991 IWC 1991
Age at first parturition	50 95	8 13	1990 1990	IWC 1991 IWC 1991
Natural mortality rate		0.10 0.09	1988 1990	IWC 1989 IWC 1991

5.3 Catch data

Catch data used in the assessments were compiled by Víkingsson and presented in Table 5.3.1. The CIC subarea comprises the coastal shelf of Iceland and the Central Medium Area is the union of small areas CIP, CG, CIC and CM; all these are defined in IWC (1994), and shown in Figure 5.1.1. The Central Medium Area catches include catches taken by Inuits at East Greenland, as supplied by Barner Neve.

Table 5.3.1. Catch data for minke whales in the Central Medium Area and CIC subarea.

Year	Central Medium Area		CIC subarea		Year	Central Medium Area		CIC subarea	
	Male	Female	Male	Female		Male	Female	Male	Female
1930	5	5	5	5	1964	208	114	114	48
1931	3	3	3	3	1965	194	206	80	62
1932	3	3	3	3	1966	181	173	87	77
1933	3	3	3	3	1967	315	159	135	87
1934	3	3	3	3	1968	386	350	219	206
1935	3	3	3	3	1969	171	120	93	66
1936	1	0	1	0	1970	203	159	112	81
1937	1	0	1	0	1971	172	131	121	98
1938	0	0	0	0	1972	204	166	115	87
1939	0	0	0	0	1973	250	127	78	64
1940	0	0	0	0	1974	143	109	61	63
1941	7	7	7	7	1975	180	221	89	80
1942	7	8	7	7	1976	175	110	114	87
1943	7	7	7	7	1977	107	88	106	88
1944	7	7	7	7	1978	146	162	85	114
1945	7	7	7	7	1979	166	118	111	87
1946	18	15	18	15	1980	198	120	121	81
1947	27	18	27	18	1981	129	117	119	82
1948	56	43	56	43	1982	212	109	127	85
1949	59	52	56	48	1983	164	125	117	87
1950	18	15	18	15	1984	136	149	100	78
1951	20	18	20	18	1985	113	123	94	51
1952	21	19	21	19	1986	6	46	0	0
1953	20	18	20	18	1987	12	42	0	0
1954	20	18	20	18	1988	4	1	0	0
1955	25	33	24	27	1989	1	0	0	0
1956	26	21	23	21	1990	5	0	0	0
1957	25	21	24	21	1991	5	2	0	0
1958	23	21	23	21	1992	8	0	0	0
1959	33	28	24	21	1993	7	8	0	0
1960	37	32	30	23	1994	8	38	0	0
1961	120	61	71	34	1995	6	38	0	0
1962	164	125	78	50	1996	12	40	0	0
1963	114	105	69	54					

5.4 Abundance estimates

The NAMMCO Scientific Committee Working Group on Abundance Estimates had at its meeting in February 1997 reviewed and analysed data collected during NASS-95, including presentation of synoptic distributional maps as well as abundance of minke whales in the Northeast Atlantic (NAMMCO/7/6). Estimates for the Central Medium Area and the CIC subarea are given in Table 5.4.1. The part of the estimate for the Central Medium Area based on Icelandic shipboard surveys is not corrected for whales missed on the track line (g(0) assumed to equal 1). The Icelandic shipboard surveys were conducted with only one platform on each of two ships, thus no data could be collected to estimate the negative bias introduced by the assumption of g(0) = 1.

As can be seen from Table 5.4.1, the 1987 and the 1995 point estimates for the Icelandic coastal area CIC differ by a factor of about 2.8. A large part of the difference is due to the fact that the 1987 aerial survey covered a substantially smaller area than the aerial survey in 1995. Also, the continuity in distribution of minke whales from Icelandic coastal areas towards the ice edge at Greenland and Jan

Mayen may allow substantial movements in and out of the aerial survey area. No conclusion can be reached on whether the difference is due to a change in abundance, local movements or methodological differences.

Table 5.4.1. Abundance estimates for minke whales in the Central Medium Area and the CIC subarea

Estimate, ref. year	c.v. of estimate	lower 95% c.l.	upper 95% c.l.
Central Medium Area			
1995: 72,130	0.244	44,711	116,362
CIC - Iceland coastal waters			
1987: 20,096	0.20	13,579	29,741
1995: 55,922	0.31	30,458	102,674

5.5 Assessments

The Working Group had before it SC/6/MP/2 which contained a series of population trajectories produced by using the Hitting-with-fixed-MSYR model and with projections for 1997-2001 for different assumptions on annual catch options. The catch options investigated were:

(a) 0 catches;
(b) 35, which is the average for the most recent 5-year period in the Central stock area;
(c) 185, which is the annual average catch over the period 1961-85 within Icelandic coastal waters (CIC);
(d) 292, which is the average over the period 1980-84 in the Central stock area;
(e) 451, which is the average over the Central stock area's most intensive catching period 1965-1969.

The MSYR assumption of 0 was run only to show the effect of accumulated catches on the population trajectories. A recent paper by Schweder and Hjort (1997) had investigated the population dynamics of minke whales in the Barents Sea by a likelihood synthesis of a relative abundance series and two abundance estimates combined through a population dynamics model. They found a point estimate of MSYR of 1.7% with a 95% likelihood contour of 0.2% - 3%. This estimate relates to the 1+ population, while the MSYRs used in SC/6/MP/2 refers to the mature stock, which implies that MSYRs are proportionally higher. The Working Group subsequently focused on runs based on MSYRs of 2% and 3%.

The total Central stock is at present close to its carrying capacity as judged from the population modelling conducted. The total stock estimate from the 1995 surveys includes a shipboard component from the Icelandic vessel survey not corrected for g(0) (that is, animals missed on the trackline), and thus considered to be conservative. For the MSYR values considered by the group as the most probable (2% and 3% of mature stock), present removal levels are of no concern. The highest past removal level projected, that is an annual catch of 451 whales, would cause concern if the total abundance is at the lower range of its estimated 95% confidence interval (i.e. 44,751 minke whales). The Working Group therefore concluded that the total Central stock is now close to its carrying capacity, and that present as well as past catch levels with the exception of the highest catch level projected, will not adversely affect this stock.

The group then decided to consider the coastal waters of Iceland, CIC, as a unit with all the projected catches taken within that area. The lower 95% confidence limit for the CIC 1995 point estimate of 55,922 minke whales, that is 30,458 whales, was considered as a conservative approach in evaluating the status of the stock. This lower 95% estimate is consistent with the 1987 estimate when the limited coverage in 1987 is accounted for (Borchers et al. 1997). All projections showed that the stock in 2001 would not be adversely affected by past or present removal levels at parameter values considered to be appropriate by the group. However, the group considered the catch level of 451 in the CIC area, corresponding to the highest catch levels taken from the total Central stock, as too high and unsustainable in the long run. Also the catch projection based on an annual catch of 292 whales may be unsustainable. The Working Group concluded that the feeding stock of minke whales in Icelandic coastal waters (CIC) is presently close to its carrying capacity, and that present as well as past catch levels with the exception of the two highest catch levels (annual catches of 292 and 451 whales) projected, will not adversely affect this stock. Summary statistics for Hitting-with-fixed-MSYR calculations including five-year projections are given for a selection of options in Table 5.5.1. Some example trajectories for a range of MSYRs of 0-6% hitting the 1995 point estimate of 55,922 minke whales and its 95% confidence limits within the Icelandic coastal area CIC, and projected annual catches of 185 whales (the annual average over the period 1961-1985 within CIC) over the period 1997-2001, are shown in Figure 3.

Table 5.5.1. Summary statistics for a selection of Hitting-with-fixed-MSYR calculations. MSY is the maximum sustainable yield in terms of harvesting of the recruited component of the population; K^e is the pre-exploitation size of the recruited component of the population; N^e_{97} is the size of the recruited component of the population at the start of 1997; N^e_{02}/K^e is the ratio of the size of the recruited component of the population at the start of 2002 to the corresponding pre-exploitation level - results are shown for this statistic for each of the five levels of future catches.

					N^e_{02}/K^e				
					Annual catch 1997-2001				
MSYR, %	MSY	K^e	N^e_{97}	N^e_{97}/K^e	0	35	185	292	451
1995 abundance estimate Central Medium Area									
Point estimate 72,130									
2	589	49103	46973	0.96	0.97	0.96	0.95	0.94	0.93
3	867	48151	46975	0.98	0.99	0.98	0.97	0.96	0.95
Lower 95% confidence limit 44,711									
2	375	31265	28987	0.93	0.94	0.94	0.92	0.91	0.89
3	545	30284	28979	0.96	0.97	0.97	0.95	0.94	0.92
Upper 95% confidence limit 116,362									
2	936	78029	75991	0.97	0.98	0.98	0.97	0.97	0.96
3	1388	77098	76000	0.99	0.99	0.99	0.98	0.98	0.97
1995 abundance estimate CIC, Icelandic coastal waters									
Point estimate 55,922									
2	452	37671	36537	0.97	0.98	0.97	0.96	0.95	0.93
3	668	37129	36542	0.98	0.99	0.99	0.97	0.96	0.94
Lower 95% confidence limit 30,458									
2	253	21053	19832	0.94	0.96	0.95	0.92	0.90	0.87
3	369	20492	19831	0.97	0.98	0.97	0.95	0.93	0.90
Upper 95% confidence limit 102,674									
2	820	68295	67209	0.98	0.99	0.99	0.98	0.97	0.96
3	1220	67765	67217	0.99	1.00	0.99	0.98	0.98	0.97

5.6 Recommendations for future research

Based on the discussions above, the Working Group considered that future research should primarily focus on resolving the questions on stock structure and population monitoring.

Stock structure

While recognising that there is some evidence of population heterogeneity in North Atlantic minke whales, it is evident that no conceptual model of dispersal and mixing of the whales can be proposed on the basis of present knowledge. Specifically such a model should

(i) identify segregation on breeding/wintering grounds, if any;
(ii) estimate the level of exchange between segregations;
(iii) estimate the mixing of putative stocks on feeding grounds and in areas with harvesting; and
(iv) identify philopatry of subunits of minke whales.

The research needed to elucidate these components of the population structure model should include a variety of techniques ranging from genetic studies, telemetric tracking of individual whales and isotope techniques to studies of levels and compositions of persistent pollutants. Some of these studies are in progress, while others will depend on the further development of techniques that are at present still in their infancy. Most research conducted so far has relied upon sampling of the whales from the harvest or at the harvesting grounds. Understanding of the population structure of North Atlantic minke whales will, however, require sampling on the wintering grounds and in areas without harvesting, in addition to sampling from the harvest.

Population monitoring

Sighting surveys are fundamental for the calculation of sustainable harvest levels and they need to be repeated at frequent intervals in areas where harvesting takes place. The abundance of minke whales in coastal areas of Iceland (area CIC) seems to have increased between 1989 and 1995 but the results are not conclusive due to the variability associated with the surveys. It would, however, be important to follow the changes in abundance in that area more closely to reveal whether the changes are due to a general increase in abundance or to temporal variability in the distribution of the whales and to possible problems in abundance estimation methodology. Likewise a comparison should be made between shipboard and aerial surveys.

6. OTHER BUSINESS

There was no other business.

7. ADOPTION OF REPORT

The report was adopted by correspondence on 15 December 1997.

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Figure 1. Map showing the IWC small areas. ES, EB, EC and EN constitute together a medium area which taken together is the Northeastern stock area, while CM, CIC, CG and CIP constitute the Central medium area.

Figure 2. Map showing the approximate locations of samples used in the genetics studies reviewed.

Figure 3. Population trajectories hitting the 1995 point estimate, as well as lower and upper 95% confidence limits, for the Icelandic coastal area CIC, and projecting the population for annual catches of 185 whales over the period 1997-2001. Trajectories are given for a range of MSY rates of 0-6%.

Appendix 1 - List of participants

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Appendix 2 - AGENDA

1. Opening remarks and terms of reference
2. Adoption of agenda
3. Appointment of rapporteur
4. Review of available documents and reports
5. The Central North Atlantic minke whale stock
    - 5.1 Stock structure
    - 5.2 Biological parameters
    - 5.3 Catch data
    - 5.4 Abundance estimates
    - 5.5 Assessments
    - 5.6 Recommendations for future research
6. Other business
7. Adoption of report

Appendix 3 - List of documents

SC/6/MP/1	Daníelsdóttir, A.K. 1997. Review on the population genetic structure of North Atlantic minke whales (*Balaenoptera acutorostrata*).
SC/6/MP/2	Punt, A. 1997. Implications of various levels of future catches on the dynamics of population of minke whales in the Central North Atlantic.
SC/6/MP/3	Víkingsson, G.A. 1997. Biological parameters of Central North Atlantic minke whales.
SC/6/MP/4	Palsbøll, P.J. 1997. Review for NAMMCO of manuscript by Anna Daníelsdóttir, entitled; “Review on the population genetic structure of North Atlantic minke whales (*Balaenoptera acutorostrata*)”.

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