NAMMCO/7/6

# SCIENTIFIC COMMITTEE

## REPORT OF THE FIFTH MEETING

**Tromsø, Norway, 10-14 March 1997**

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The Scientific Committee of NAMMCO met in the Grand Nordic Hotel, Tromsø, Norway from 10 to 15 March 1997. The meeting was attended by members of the Scientific Committee and scientific observers from Japan and Norway, as well as a number of invited experts to Scientific Committee Working Groups. A full list of participants is contained in Appendix 1.

## 1-3. OPENING PROCEDURES

The Chairman, Tore Haug, welcomed members and observers to Tromsø and to the meeting. On behalf of the Committee, he welcomed in particular the two new members of the Committee, Pia Barner Neve for Greenland, and Lars Folkow, who replaced Arne Bjørge as member for Norway in 1996. For the benefit of new participants, the Chairman requested introductions all round.

The Chairman referred to both recent and outstanding requests for advice forwarded from the Council which formed the agenda for the present meeting. He noted that the Committee had most recently been assigned the important tasks of focusing on more specific items related to the role of marine mammals in the ecosystem. These included an examination of the food consumption of three major marine mammal predators in the North Atlantic, as well as a review of the current state of knowledge of sealworm infestation in fish. The Committee had agreed through correspondence prior to the meeting to establish *ad hoc* Working Groups under the chairmanship of Gísli Víkingsson (Iceland) for food consumption of minke whales, harp seals and hooded seals, and Geneviève Desportes (Faroes) for sealworm infestation, to deal with these questions (see under item 7 below). He further welcomed the participation of a broad range of external expertise represented by scientists from Canada, Denmark, Iceland, Norway and the UK who would be contributing to the work of the Working Groups.

The Chairman further noted that the Committee would also be dealing with the report of the Working Group on Abundance Estimates, which had only recently completed the task assigned to it to review the results of NASS-95 and provide updated abundance estimates for whale stocks in the North Atlantic. A further request for an assessment of the status of the Central Atlantic minke whale stock had been added to the agenda just prior to the meeting, and the Committee would also use this meeting to discuss how best to deal with this matter.

The Agenda, as contained in Appendix 2, was adopted and the Secretary, Kate Sanderson, was appointed as rapporteur.

The Secretary informed the Committee of the practical and social arrangements for the meeting, which included a Chairman=s dinner on the Tuesday evening, which was sponsored by the following Norwegian institutions and organisations: the University of Tromsø, the Norwegian Institute for Fisheries and Aquaculture, the Norwegian Ministry of Fisheries, Råfisklaget, the Shipowners= Association of Northern Norway and Tromsø City Council.

## 4. REVIEW OF AVAILABLE DOCUMENTS

### *4.1 National Progress Reports*

National Progress Reports for 1996 from the Faroes, Iceland and Norway, and for 1995 from Greenland (SC/5/NPR - F,G,I & N) were submitted to the Committee.

Dorete Bloch, member of the Committee for the Faroes, had pointed in correspondence to the usefulness of including strandings and sightings data in National Progress Reports (SC/5/14). The Committee noted that while such data was not required according to the adopted Guidelines for the Content and Format of National Progress Reports (see *NAMMCO Annual Report 1996*, p.134), the extent of systematic recording of such data varied from country to country. It was further noted that in the Faroes and Iceland, incidental strandings and opportunistic sightings data were collected to a greater extent than was possible in Greenland and Norway, and that such data had already been included in National Progress Reports submitted to the Scientific Committee in previous years. It was decided that the inclusion of such data should be left up to the discretion of those responsible for compiling the respective National Progress Reports to NAMMCO.

### *4.2 Working Group reports & other documents*
Working Group and other reports available to (and during) the meeting are listed in Appendix 3.

## 5. COOPERATION WITH OTHER ORGANISATIONS

### *5.1 ICES*
The Chairman noted that ICES had now provided its final advice to NAMMCO on the request for an assessment of the long-finned pilot whale, forwarded to ICES from the Council in 1992 (see *NAMMCO Annual Report 1996*: 132). This was based on the work of the ICES Study Group on Pilot Whales, which had met for the third and final time to complete its work in Cambridge, UK in April 1996 (see under item 8.1).

The Secretary informed the Committee that negotiations were under way with ICES to develop a memorandum of understanding between NAMMCO and ICES. It had been suggested by NAMMCO that this should be a general agreement on cooperation and exchange of information, and further discussions on the issue were expected in the near future.

### *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 recently received the report of the last meeting of the ASCOBANS Advisory Committee, at which Arne Bjørge (former Committee member for Norway) had reported on the 1996 meeting of the NAMMCO Scientific Committee. It was noted in this connection that the Scientific Committee has no arrangement with ASCOBANS for an exchange of observers on a scientific level (see also 5.8).

### *5.5 Canada/Greenland Joint Commission on the Conservation and Management of Narwhal & Beluga*
The Secretary informed the Committee that reports were now being exchanged on a regular basis with the Canada/Greenland Joint Commission on the Conservation and Management of Narwhal and Beluga. The report of the December 1995 meeting of the Commission and the June 1995 meeting of the Scientific Working Group were now available. The next meeting of the Scientific Working Group was expected to take place in the summer of 1997, once data from a recent beluga survey were complete, and the Commission was likely to meet again in late 1997.

### *5.6 Arctic Monitoring & Assessment Programme (AMAP)*
With reference to last year=s recommendation from the Committee for NAMMCO to exchange information with organisations which are assessing the status of the Arctic environment, the Secretary informed the Committee that information was exchanged regularly with the Secretariat of the Arctic Monitoring and Assessment Programme (AMAP) in Oslo. The final AMAP assessment report on contaminants in the Arctic would be the focal point of the AMAP International Symposium on Environmental Pollution of the Arctic & Third International Conference on Environmental Radioactivity in the Arctic, to be held in Tromsø, 1-5 June 1997. Copies of a preliminary programme for the Conference were available at the Committee meeting. The Secretariat planned to follow proceedings in Tromsø in

June, and would endeavour to obtain copies of the final AMAP assessment report for distribution to Committee members.

### *5.7 International Union for the Conservation of Nature (IUCN)*

Referring to information provided to the Committee at last year=s meeting concerning the establishment of working relations with the IUCN through its Species Survival Commission (SSC) Cetacean and Seal Specialist groups, the Secretary informed the Committee of her discussions with members of the SSC Secretariat during the IUCN World Conservation Congress in Montreal in October 1996. These contacts would be pursued in the near future, and further information exchanged with IUCN.

The Committee discussed briefly the new IUCN Red List of Threatened Animals, which is a global status of species defined under three main categories of Critically Endangered, Endangered and Threatened, based on a set of revised criteria which were adopted at the 1994 General Assembly of IUCN (Baillie and Groomsbridge, 1995). The Committee noted with concern the inappropriateness of producing status assessments on a global/species basis rather than on a stock basis.

### *5.8 Other matters - Observers*

The Committee discussed the question of admission of observers to its meeting, noting that the Rules of Procedure for the Committee state that observers shall not be permitted at meetings of the Scientific Committee unless otherwise decided by the majority of the Committee and approved by the Council. It was, however, noted that despite this restrictive rule, observers had attended Committee meetings previously and two observers were present at this meeting, whose attendance had been cleared by the Committee prior to the meeting.

The Committee agreed that prospective observers at its meetings should submit a request in writing to the Secretariat stating their affiliations and reasons for wishing to attend, in order to provide Committee members with a proper basis on which to decide on their admission.

A question was also raised concerning the role of observers at Scientific Committee meetings, as this was not made explicit in the Rules of Procedure. It was agreed that observers could be invited to make comments and contribute to the discussions.

## 6. UPDATE OF LIST OF PRIORITY SPECIES

As agreed at the last meeting of the Scientific Committee, a draft update of the List of Priority Species had been prepared for the meeting, which incorporated new data on species and stocks provided by various members of the Committee and compiled by the Secretariat.

Further development of the List was discussed by the Committee under Agenda item 10 in relation to the Council=s request to the Scientific Committee to monitor stock levels and trends in stocks of all marine mammals in the North Atlantic.

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, and that agenda items 6 and 10 should in future be merged (see further under item 10).

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

### *7.1 Food consumption of minke whales, harp seals and hooded seals in the North Atlantic and interactions with fish stocks*

The Chairman referred to the request from the Council to the Scientific Committee -

A    to focus its attention on the food consumption of three predators in the North Atlantic: the minke whale, the harp seal and the hooded seal, with a particular emphasis on the study of the potential implications for commercially important fish stocks≅ (*NAMMCO Annual Report 1996*:28)

A Working Group on the Role of Minke Whales, Harp Seals and Hooded Seals in North Atlantic Ecosystems (SC/5/ME) was established under the chairmanship of Gísli Víkingsson (Iceland). The Working Group convened from 10-14 March, with the participation of, and contributions by members of the Committee and a number of invited experts from Canada, Iceland, Norway and Russia. Víkingsson presented the report of the Working Group to the Committee, which was circulated as SC/5/9. The final report of the Working Group is contained in Annex 1 of this report.

### 7.1.1. Feeding ecology

***Minke whales***

The Committee noted that, except for the Northeast Atlantic, the diet composition of minke whales has been rather poorly documented in recent years.

Studies on the diet composition of minke whales off northern Norway, in the Barents Sea, and around Spitsbergen have shown large year-to-year variations. Recent studies, based on years with low capelin abundance (1992-1995), have identified herring and krill as the most important food items, followed by cod and various other fish species. In this area minke whales are estimated to consume 1.8 million tons of prey during the period April-October. Of this estimate 633,000 tons were herring, corresponding to about 70% of the total 1995 fishery for that species.

From the little available information, minke whales in Icelandic waters appear to feed on fish and krill in roughly equal amounts. The identified fish species were capelin, sand eel and cod. The total consumption of the species in this area, (based on abundance estimates from the 1987-1989 surveys) was estimated as 391,000 tons, of which 198,000 tons were fish.

In Greenland waters capelin is the most important food species for minke whales. Among other identified prey species were Atlantic cod, polar cod, Greenland cod, herring, sand eel and crustaceans.

In the Northwest Atlantic off Canada, capelin appears to be the dominant prey species of minke whales, while other identified food items include squid, salmon, herring, cod and crustaceans. A preliminary estimate indicates that the consumption of minke whales in Canadian waters is relatively low compared to that of harp seals, although it may be larger than the consumption of hooded, grey or harbour seals in the area.

***Harp seals***

Diet composition of harp seals in the Barents Sea varies substantially between areas and time periods. In general the most important prey groups are crustaceans, capelin, polar cod and herring. The total consumption of the Barents Sea harp seal stock was estimated as 1.1-1.7 million tons depending on the choice of input parameters in the model. Assuming a variable basal metabolic rate (BMR) throughout the year and a field metabolic rate of 2*BMR the estimated annual consumption by harp seals is 428,200 tons of crustaceans, 258,200 tons capelin (in years of high capelin abundance), 212,500 tons polar cod, 69,600 tons herring and 32,200 tons cod. In years of low capelin abundance capelin consumption seemed to be replaced by other fish species, notably polar cod.

Most of the examined harp seals from the Greenland Sea pack ice during spring and early summer had empty stomachs but analysis of the intestines revealed *Themisto sp*. as the major food item. The main prey species identified in harp seals collected during February-May in coastal North Icelandic waters were sand eels, cod fishes and capelin.

The food composition of harp seals in West Greenland waters is variable, with pelagic crustaceans, capelin and polar cod as the most important prey types. Although commercially important fish species are a small part of the diet, the total consumption of these may be of the same order of magnitude as the commercial fishery in the region.

Harp seals are considered the most important pinniped predators in Atlantic Canadian waters. In the northern Gulf of Maine and NAFO areas 2J3KL they were estimated to have consumed over 150,000 tons of Atlantic cod, 1.1 million tons of capelin, 600,000 tons of polar cod, 130,000 tons of Greenland halibut, 107,000 tons of redfish and 104,000 tons of herring in 1996. The greatest source of uncertainty in the estimates of consumption by harp seals in the Northwest Atlantic is related to limited information on seasonal distribution of the species and potential spatial and temporal variations in the diet.

***Hooded seals***
The diet composition of hooded seals is not generally as well known as that of harp seals.

The majority of hooded seals sampled in the Greenland Sea pack ice during spring and early summer had empty stomachs, but the major food item found in the intestines was the squid *Gonatus fabricii*. Redfish, cod and other fish species were the main prey species identified in a small number of hooded seals investigated off northern Iceland.

In Greenland waters, larger demersal fish species like Greenland halibut, redfish, cod and wolffish are apparently important prey items for hooded seals, in addition to the species also taken by harp seals in the area.

In Atlantic Canada hooded seals were estimated to consume 129,000 tons of Greenland halibut, 36,000 tons of Atlantic cod and 19,000 tons of redfish in 1996.

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The Scientific Committee noted that a number of uncertainties were identified in relation to the estimates of consumption in the different species/areas and it was stressed that these estimates should therefore be used with caution.

#### 7.1.2. Interactions between marine mammals (minke whales, harp and hooded seals) and commercially important fish stocks - multispecies modelling

A multispecies model for the Barents Sea (MULTSPEC) describes the interactions between minke whales, harp seals, herring, capelin and cod in the Barents Sea. The main effects identified were:

- The herring stock increased as predation from marine mammals decreased;
- The development of the capelin stock was mainly determined by changes in the herring and cod stocks;
- Generally, the cod stock increased or decreased when marine mammal stocks decreased or increased;
- Decreasing the preference for herring by cod had much larger effects than changing some of the marine mammal preferences.

It was noted that the model might be improved by including polar cod and taking account of seasonal variation in prey preferences.

Another model investigated the effect on fish stocks of tuning the Revised Management Procedure (RMP) for minke whales in the Barents and Norwegian Seas from the current level of 72% of k (carrying capacity) to 60% k. Assuming an abundance of 100,000 minke whales and a Maximum Sustainable Yield Rate

(MSYR) of between 1% and 2%, the main effect of changing the RMP target from 72% to 60% was an increase of some 14% in the cod catches.

Investigations on interactions between three whale species, two seal species and two fish species in Icelandic waters indicate that natural morality of cod from marine mammal predation is twice that which is due to cannibalism and thus may be a major portion of natural mortality in the younger age classes.

The Scientific Committee noted the conclusions of the Report of the Workshop on Harp Seal-Fishery Interactions in the Northwest Atlantic: Toward Research & Management Actions (St. John=s, Newfoundland, 24-27 February 1997), which became available during the meeting and was reviewed by the Working Group (SC/5/13; Annex 1, item 5.4).

The Scientific Committee noted that the effects of marine mammals are at present not included in models routinely used in multispecies management. A number of potential uses of multispecies models were identified, as well as the most important gaps in knowledge and data requirements for the modelling work (see Annex 1, item 5.5).

#### 7.1.3 Recommendations for future work

Based on results of studies reviewed by the Working Group, the Scientific Committee concluded that minke whales, harp and hooded seals may have substantial direct and/or indirect effects on commercial fish stocks. To better understand these effects, the Scientific Committee **recommended** the following:

1) For each species, knowledge should be improved of seasonal, annual and spatial variations in: abundance; distribution; diet; energy requirements; and prey abundance. Knowledge of each of these factors varies between areas and species. The extent of existing knowledge in these areas was noted by the Working Group in its report (Annex 1), and should be considered when developing specific research plans.

2) Understanding of prey selectivity and responses to changes in prey abundance by these predators should be improved. Little is known about these processes at the present time.

3) Estimates of consumption by other important predators should be obtained and the degree of potential competition assessed.

4) Multispecies models should be improved by:

- incorporating uncertainty in the parameters (e.g. stock estimates, food preferences, migration) to provide a realistic estimate of the total uncertainty;
- incorporating variations in migration and prey selection. An understanding of these processes is important, but they are not understood at present;
- constructing models on the appropriate spatial and temporal scale for the various components.

5) Efforts to construct multispecies models in the Northwest Atlantic should be encouraged.

In conclusion, the Scientific Committee **recommended** that relevant scientific papers reflecting the present state of knowledge of the role of marine mammal predators in North Atlantic ecosystems, as reviewed by the Scientific Committee, should be published as a volume in the NAMMCO scientific publication series. The Chairman of the Working Group, Gísli Víkingsson, agreed to take on the task of editing such a volume, and would seek the assistance of an appropriate co-editor.

### *7.2 Sealworm infection*

The Chairman referred to the Council=s request to the Scientific Committee -

A to review the current state of knowledge with respect to sealworm infestation and to consider the need for comparative studies in the western, central and eastern North Atlantic coastal areas, taking into account the priority topics recommended by the Scientific Committee and its *ad hoc* Working Group on grey seals (*NAMMCO Annual Report 1996*: 28; 111-116).

To address this request, a Working Group on Sealworm Infection (SC/5/SI) was established under the chairmanship of Geneviève Desportes (Faroes). The Working Group convened from 10-14 March, and was attended by a number of scientific experts from Canada, Iceland, Norway and the UK who had been invited to contribute working papers to the Working Group=s review of sealworm infection in the North Atlantic. Desportes presented the report of the Working Group to the Committee, which was circulated as SC/5/10. The final report of the Working Group is contained in Annex 2 of this report.

**7.2.1 Review of the current state of knowledge**

It was noted that as basis for its review, the Working Group took as its starting point the proceedings of an earlier sealworm workshop (Bowen 1990) and agreed to emphasise those areas where further progress had been made since this workshop.

*i) Life cycle*

As the number of species investigated increases, so too does the number of possible intermediate sealworm hosts, both invertebrate and fish.

New information on naturally infected small benthophagous fish species shows that the density of infection in these can be very high. This indicates the magnitude of the long-lived sealworm reservoir in the environment.

In seals, individual worm fecundity increases with worm length, and there was so far no evidence of a reduction in worm fecundity with total or individual species worm burden. Experimental egg hatching rates are greater than 90%.

*ii) Environmental factors influencing the life cycle*

Sealworm eggs do not hatch in water temperatures below 0EC. This may explain a decline in sealworm infection observed in grey seals, cod and plaice, following a period of cold waters in the Gulf of St Lawrence after 1990, and on the Breton and Scotians shelves and in the Gulf of Maine. However it was noted that temperature could only affect the level of sealworm infection at the northern edge of the distribution range.

Sealworm infections are prevalent on the continental shelf but are not found in deeper water systems, such as beyond the shelf edge and in some Norwegian fjords.

The species composition of invertebrate and small fish communities varies substantially with substrate type, and causes extensive local variability in infection levels.

*iii) Behavioural factors influencing the life cycle*

Both in invertebrates and fish, infected hosts have been shown in some systems to be more susceptible to predation than non-infected ones. This will influence the transmission rate between hosts. Persistent differences in individual foraging behaviour in seals have been shown to influence greatly the level of infection in individual seals and may explain some of the variability of sealworm abundance in seals.

*iv) Influence of seal abundance on the level of infection in fish*

Based on the findings of the Working Group, the Scientific Committee concluded that:

1) The presence of either grey seals or harbour seals can lead to sealworm infections in fish over the entire North Atlantic region. Reduction of either species may not therefore result in a significant reduction in sealworm infections in fish;

2) Although harbour seals are less abundant than grey seals in many areas, they could be responsible for high local infections in fish because of their limited foraging range;

3) At least in the short and medium term, sealworm infection levels in intermediate hosts are not necessarily directly correlated with seal abundance. They may be mitigated by other factors such as environmental temperature and intermediate host abundance and distribution;

4) Individual worm levels in seals vary to such an extent that a few seals could still maintain high infection levels in fish.

#### 7.2.2 Need for comparative studies

In order to test the universality of sealworm models, there is a need not so much for purely comparative studies, but for comparable datasets in the western, central and eastern North Atlantic coastal areas. This can only be achieved through the development of long-term databases on sealworm infections for systems in the Northeast and Central Atlantic, and the development of comparable datasets for inshore systems from the Northwest Atlantic.

There is also a need to categorize habitat types (substrate, vegetation, invertebrate and fish communities) in order to compare infection rates between seal and fish populations.

#### 7.2.3 Future work

i) Considering the incompleteness of information in some specific areas of the sealworm life cycle and dynamics, the Scientific Committee **recommended** that research efforts on sealworm biology and dynamics be intensified both in the Northeast and Northwest Atlantic, in particular with regard to sealworm development and lifetime fecundity in the seal host, possible changes of behaviour in infected host which may increase the transmission rate between hosts, and the processing of existing samples for sealworm abundances in different fish and seal species.

ii) Considering that -

- a) very strong relationships between sealworm abundance in fish and seal population size have been observed in the Northwest Atlantic but that they may be modified by environmental changes and modifications in seal fishery interactions;
- b) historical data is available in Iceland on levels of sealworm infection in seals and cod;
- c) the grey seal population in Iceland has been reduced from 14,000 to 8,000 between 1986 and 1995; and
- d) a major survey of sealworm in Atlantic cod is under way in Iceland,

- the Scientific Committee **recommended** that an intensive survey of anisakid nematodes in grey seal stomachs in Iceland be undertaken at the same time as the Icelandic survey on sealworm in Atlantic cod.This represents a unique opportunity to examine the relationship between sealworm levels in fish and seals and a dramatic reduction in a grey seal population.

iii) Appreciating the considerable amount of new information collected both on the life cycle of the sealworm and the dynamics of sealworm infection, as well as on the population structure of the seal colonies, the Scientific Committee **recommended** that a workshop be convened, in cooperation with other relevant organisations and institutions, to undertake modelling of sealworm infection, involving both modellers and those familiar with the various biological systems in the North Atlantic.

iv) The Scientific Committee **recommended** that the material presented to the Working Group on Sealworm Infection should form the basis of a publication on sealworm infection in the North Atlantic as a part of the NAMMCO series of scientific publications. Desportes agreed to function as main editor of the volume, in collaboration with an appropriate co-editor from the field.

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

### *8.1 Long-finned pilot whales*

The Chairman referred to the request from the Council for an assessment of the state of the pilot whale stock in the Northeast Atlantic, based on information sampled from the Faroese drive fishery and the NASS sightings surveys (see *NAMMCO Annual Report 1996*: 132). This request had been forwarded to ICES, in response to which ICES had established a Study Group on Long-finned Pilot Whales. The report of final meeting of the Study Group in April 1996 in Cambridge, UK, under the chairmanship of D. Butterworth (South Africa) (SC/5/4 - ICES CM1996/A:6) was used by the Scientific Committee as the basis for its discussions under 8.1.1. below.

At its second meeting in 1993, the Council further requested the Scientific Committee to analyse the effects of the pilot whale drive hunt in the Faroe Islands on North Atlantic pilot whales, especially whether the numbers taken are consistent with sustainable utilization (*NAMMCO Annual Report 1996*: 132). This matter was addressed by the Committee under item 8.1.2 below, based on the findings of the ICES Study Group (SC/5/4) and the review of results of NASS-95 (see also under item 9).

#### 8.1.1 Assessment of status of pilot whale stock in the Northeast Atlantic

With its basis in the Report of the ICES Study Group on Long-finned Pilot Whales, the Scientific Committee reviewed the major findings and research requirements related to the assessment of the status of long finned pilot whales in the North Atlantic.

*i) Population identity and seasonal movements*

*Distributional evidence*

It was noted that new information available on abundance of the species still does not fill the gap in effort in offshore waters south of Greenland, from the shelf break east to 42EW. It was further noted that it was unfortunate that the longitudinal coverage could not have been extended in the NASS-95 survey to provide comprehensive coverage of the range of the species. It was concluded that the distributional evidence had not allowed delineation of any stock boundaries and that the area south of Greenland should be surveyed to determine if the gap in sightings data represents an actual gap in distribution.

*Genetic evidence*

No new genetic information was available for the last meeting of the Study Group. However, it was noted that the Study Group had discussed current available information, and in particular the low reported variability on mtDNA. It was noted that the explanation forwarded to the Study Group by B. Amos (Cambridge University) that if pilot whales live in strong matrilineal schools, as is suspected, then the genetically effective population size is the number of genetically related groups of animals, and not the total population. The number of such related groups is not known, but may be relatively small, in the order of several thousand. This small effective population might thus be expected to have low mtDNA variability, as is observed.

*Morphometric evidence*

Further analyses of the morphometric information available at the 1993 meeting of the Study Group and new morphometric information available on pilot whales stranded at Cape Cod allowed for a confirmation of the earlier presumption that there are significant differences in morphology between pilot whales taken in the Faroe Islands and those from Cape Cod and Newfoundland. The Scientific Committee agreed that the simplest interpretation of this conclusion is that there is more than one population of long-finned pilot whales in the North Atlantic.

*General conclusions*
Based on all available information, the Scientific Committee **agreed** that of the three hypothesis formulated and examined at the 1993 meeting of the Study Group:

1) There is only one North Atlantic population of long-finned pilot whales;
2) There is more than one such population;
3) There is only one stock in the near vicinity of the Faroe Islands, which is restricted to these waters.

the first hypothesis could be ruled out by the morphological differences seen between the eastern and western North Atlantic animals. The third hypothesis could also be ruled out; i.e. that pilot whales around the Faroes do not form a discrete localized population. This conclusion was based on the high inter-annual variability in distribution patterns in the area around the Faroe Islands, confirmed by the data from the NASS-95 survey, and the variation in pollutant loads and parasite burdens between schools of pilot whales taken in the Faroese drive fishery.

*ii) Social structure and behavioural factors*

*Difference in average group size between sightings surveys and the Faroese drive fishery*
A preliminary attempt to determine spatial structure of pilot whale schools during the Faroese NASS-95 sightings survey indicated that estimates of the size of the schools tended to increase with closer inspection, and that schools were spread out over several kilometres. The Scientific Committee noted, however, that the total number of animals in the aggregations investigated were still less than the average size of schools landed in the Faroe Islands, and that further investigation of this matter was necessary.

*Effect of harvesting whole groups of whales*
The effects of harvesting whole groups of animals which were genetically related had been explored to a certain extent. The Scientific Committee noted, however, that there does not appear to be sufficient information available about the specifics of the social processes involved in pod formation and creation, and their ecological implications, to enable concerns about the influence of the processes on the ability of pilot whales to support harvesting mortality to be completely addressed.

*iii) Estimates of abundance*

*Eastern North Atlantic*
In the light of results from NASS-95, it was concluded that the coverage of the three surveys (NASS-87, -89 and -95) was not identical and thus yielded substantially different estimates of total population abundance. However, when abundance estimates for comparable areas in 1987 and 1989 were compared, no significant differences were evident. Some of the blocks showed a significantly lower density in 1995 compared with 1989, while other blocks showed a similar density in 1989 and 1995. Comparable blocks in the 1987 and 1995 surveys also showed similar estimates of abundance. It was therefore concluded that given the mobility of the species, the apparent between-year shifts in distribution and the relatively thorough and extensive coverage of NASS-89, the estimate of 778,000 derived from this joint survey was the most appropriate (see also under 9.4).

*Western North Atlantic*
Although some new information was available on a local basis, no synoptic view of distribution and abundance of pilot whales based on systematic sightings surveys is available for the western North Atlantic.

*iv) Historical catch estimates, population dynamics parameters and population models*

*Population dynamics parameters*

In the light of the Study Group discussion, the Scientific Committee agreed that since the difference between the age at first ovulation and the age at first parturition (even the lowest estimate) is greater than the estimated length of gestation, a range of values of age at first parturition (from 10 to 14 years) should be used in population model analyses, instead of the age at first ovulation plus gestation length.

New analyses indicated that the highest fertility rates occurred in 10 year-old animals and that fertility declined with age. Animals over 32 years old were classified as reproductively senile, even though there was evidence that they continued ovulation and were still lactating. The Scientific Committee accepted these results as the best available estimates of age-specific fertility rates.

*Population modelling*
A simple population model was used to investigate the implication of three sources of information on the pilot whale population in the eastern North Atlantic. These are possible range of maximum growth rate for the species, recent estimates of abundance and historical series of catches.

A plausible upper bound for the annual growth rate was chosen as 5.7%. Since it may not be achieved in practice, computations were also carried out with maximum growth rates of 0%, 1.4%, 2.8% and 4.3%, corresponding to 25, 50 and 75% of this upper bound.

The NASS-89 surveys provided an estimate of 778,000 pilot whales in the eastern North Atlantic. Since it is not known whether the population which is effectively harvested corresponds to the surveyed population, three smaller areas from which the harvested population may be taken were also used in the computations.

The estimates of historical catches were used, assuming that the catches recorded from Greenland eastwards came from one population. Alternative assumptions would not however substantially affect the results because the non-Faroese catches are small by comparison.

The summary statistics from the ICES Study Group Report (SC/5/4) which indicate the important features of the population trajectories are shown in Appendix 6. Section 8.1.2 summarises the conclusions of the Scientific Committee.

*v) Further research recommendations*

The Scientific Committee noted with appreciation that many of the 22 research needs listed at the 1993 meeting of the ICES Study Group had since been addressed. The major uncertainties in population status are the potential and actual population rates of increase and the geographical areas over which pilot whales range.

The Scientific Committee **agreed** to endorse the list of future research requirements listed by the ICES Study Group in its report (SC/5/4: 12-14). Further, the Scientific Committee agreed that two among these should be given the highest priority:

a) A long-term research and population monitoring strategy should be developed related to the Faroe Island fishery, based on an in-depth review of previous and current fishery monitoring procedures and the extensive research conducted in the Faroe Islands since the mid 1980s. The aims of such a programme should include both longer-term monitoring which would help improve understanding of the status of the harvested population, and short-term monitoring to detect more rapid changes as might occur.

b) In order to gain more information on the size of the population subjected to the Faroese fishery, the movements of individual pods of pilot whales that approach the Faroe Islands should be monitored by use of satellite tags. Several animals within a pod should be tagged, ideally with tags designed to be active over varying time periods.

### 8.1.2 Sustainability of the Faroese catch

In discussing the sustainability of the Faroese catch of pilot whales, the Scientific Committee focused on the population trajectories provided in SC/5/4, which are contained in Appendix 3. Based on the catch history, the population trajectories predict the changes in the population size since 1840 under various assumptions of maximum population growth rates and for various stock areas, based on the population estimate resulting from NASS-89. A maximum growth rate of 0% was included in the table (upper row) to illustrate the effect of accumulated catches, but the Scientific Committee did not believe that this was a probable scenario. Similarly, the possibility that the catches were recruited solely from a local population around the Faroe Islands was considered extremely unlikely. The reason for this is that the variation in pollutants and parasite burdens between schools of pilot whales from the Faroe Islands suggest that they are not recruited from a local area, and this is further supported by the variation in abundance between surveys in this area (see under (8.1.1 - *i* ). A more plausible range of maximum population growth rates of 1.4 to 5.7% per annum was applied to the three probable stock areas; Rockall-Iceland, Mid-Atlantic Ridge-Faroes, NASS-89 Survey Area.

Having excluded the two most extreme scenarios (0% growth/yr and local Faroese population), 12 population trajectories were examined (see Appendix 6). The trajectories were fitted to the population estimates from 1989 which are in agreement with the results from 1995 for comparable areas. The historical population sizes were derived from catch statistics and the range of maximum population growth rates. The present population sizes are compared to historic population sizes derived from the trajectories and the present size is given as a fraction of historical sizes. Only for the smallest area (Rockall-Iceland) and the lowest maximum population growth rate (1.4 % per annum) considered could a decline in population size be detected. The corresponding population trajectories for this area show declines after 1940 due to higher catches around that time, but also a stabilisation during the 1950s.

The Scientific Committee **concluded** that the effects of historic and present catches in the Faroe Islands have had a negligible effect on the long-term trends in the pilot whale stock. The Scientific Committee also noted that an annual catch of 2,000 individuals in the eastern Atlantic corresponds to an exploitation rate of 0.26% of the present best estimate of the abundance of pilot whales in the Northeast Atlantic (778,000 pilot whales from NASS-89).
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While noting the recommendations for further research outlined under 8.1.1 above, the Scientific Committee considered that it had now completed its work in addressing the Council=s requests for advice on this species, based on all available information which had been thoroughly reviewed by the ICES Study Group on Long-finned Pilot Whales and the Scientific Committee with respect to the status of the pilot whale population in the North Atlantic and the sustainability of the Faroese catch.

### *8.2 Killer whales*

#### 8.2.1 Update on progress

The Chairman noted that it had not yet been possible to complete a full assessment of the killer whale as requested by the Council. Few new data were available, other than recent sightings data from NASS-95 which had not been analysed.

The Chairman drew the Committee=s attention to a recent publication by Similä et. al. (1996) on the relationship between killer whales in northern Norway and the distribution and abundance of Norwegian spring-spawning herring. It was shown that killer whales occurred in different areas during the summer and the autumn-winter, and these areas coincided with the distribution areas of herring. The present pattern of seasonal occurrence in the coastal waters of northern Norway is expected to change as a result of growth in the Norwegian spring-spawning herring stock.

#### 8.2.2 Future work

The Committee agreed that further consideration of the Council=s request for an assessment of the killer whale should wait until further data became available.

### *8.3 Harp seals*

The Committee had little new information to add to last year=s comprehensive review of available data on the harp seal, in particular in the Northwest Atlantic (see *NAMMCO Annual Report 1996*: 104-107).

It was noted, however, that the ICES/NAFO Joint Working Group on Harp and Hooded Seals would be meeting again later this year to look in particular at outstanding aspects of NAMMCO=s request with respect to harp and hooded seals in the West Ice and harp seals in the East Ice. It was therefore expected that the Committee would be in a position to return to these items at its next meeting in 1998.

It was noted that an aerial survey of harp seals in the White Sea was currently under way by Russian scientists, and it was hoped that this would provide information on pup production levels with which to develop an abundance estimate for the White Sea stock.

Folkow (Norway) also reported that some tagging of harp seals in the White Sea had been done in May 1996 in cooperation with Russian scientists with the aim of investigating migrational patterns between moulting and breeding seasons and distribution throughout the season.

### *8.4 Hooded seals*

The Committee noted, as above under 8.3, that the ICES/NAFO Joint Working Group would be meeting again later this year, and that there was as yet nothing new to add to information reviewed at last year=s meeting.

Øien (Norway) reported on a forthcoming survey of hooded seal pups in the West Ice, using aircraft, helicopters and a coastguard vessel. It was expected that results from this survey would provide the data necessary for estimating abundance of the stock.

### *8.5 Harbour porpoises*

The Chairman referred to the Committee=s recommendation at its last meeting for a comprehensive review of the harbour porpoise, and the Council=s endorsement of the inclusion of this species on the agenda of the Scientific Committee in the future. No specific request had, however, been forwarded from the Council.

The Committee noted that this species was 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 harbour porpoise throughout its range, should the Council decide that this is an appropriate task for the Scientific Committee.

### *8.6 Central North Atlantic minke whales*

The Chairman referred to the following request recently forwarded to the Scientific Committee:

AIn 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.≅

As the request had only recently been received, the Committee began by discussing how best to deal with the task.

*i) Estimate of abundance*

With respect to abundance of the stock, the Committee noted the revised estimate of 72,000, based on the recent review of NASS-95 data (see under 9), and considered this as the best available estimate for the Central North Atlantic stock.

*ii) Assessment of the status of the stock*

It was noted that an earlier attempt to assess this stock had been carried out by the IWC Scientific Committee in 1990, which had agreed that A if the results of the runs of the HITTER model for the Central stock as at present defined are used as a basis for assessment, the Central stock of minke whales in the North Atlantic should be classified as an Initial Management Stock.≅ (*Rep.Int.Whal.Commn 41*,1991:68). The Committee noted that this assessment had been based on a considerably lower abundance estimate (28,000) than what was now available, and that new information on stock discreteness and catch levels was also available for use in assessing the status of the stock.

The Scientific Committee agreed to assign the task of assessing the status of the stock to the Working Group on Management Procedures, under the chairmanship of Nils Øien (Norway). Preliminary discussions were held during the meeting by members of the Working Group (Barner Neve, Gunnlaugsson, Heide-Jørgensen, Øien). The resulting proposal for how to proceed with the work was endorsed by the Scientific Committee:

To provide the requested assessment of the status of the Central North Atlantic minke whale stock, the Working Group on Management Procedures would:

1) provide a summary of completed work and ongoing studies of the stock discreteness of central North Atlantic minke whales;
2) examine past history of exploitation under varying assumptions of recent population size, maximum population growth rate and stock areas to be decided under i);
3) examine a range of management scenarios of present removals under most likely stock areas and with results from NASS-87, -89 and -95.

It was further noted that in order to carry out this work, the Working Group would need to contract the relevant expertise to summarize genetic results and to run population trajectories.

With regard to the time frame for undertaking this work, it was pointed out that the Council had requested the Scientific Committee to provide its advice on this matter prior to the next meeting of the Council. Although it was the general view of the Committee that it was unlikely that this work could be completed in time for the Council meeting, it was nevertheless agreed that effort should be made to complete the assessment as soon as possible.

## 9. REVIEW OF RESULTS OF NASS-95

The Chairman noted that at its 5th meeting in Nuuk (February, 1995), the Council had agreed to the following:

> AThe 1995 North Atlantic Sightings Survey (NASS-95) would provide updated abundance estimates for a number of whale species in the North Atlantic, and the Scientific Committee was requested to review results in the light of recent assessments of North Atlantic whale stocks.≅

To address this request, a Working Group on Abundance Estimates had been established with the task of reviewing the analyses, and where relevant, also to analyse data from NASS-95 to provide a basis for calculating abundance estimates for the relevant cetacean stocks in the North Atlantic. The Working Group began its work in 1996 by correspondence under the Chairmanship of Jóhann Sigurjónsson (Iceland), and was subsequently chaired by Nils Øien. A meeting was held in Reykjavik 20-23 February 1997, which was attended by members of the Working Group from Greenland, Iceland and Norway and invited experts from the UK. Øien presented the Working Group report to the Committee, which was circulated as SC/5/11 and is contained in Annex 3.

The Committee noted that the Working Group had focused on describing synoptic distributions of the cetacean species encountered during NASS-95, and abundance estimates for minke, fin, sei and pilot whales, which were the target species of the survey. The NASS-95 survey took place from late June to early August 1995 (see also *NAMMCO Annual Report 1996*: 116-119).

Survey methodology and data analysis for the respective survey areas and target species are described in Annex 3 (item 3). The on-effort track lines for all survey areas are shown in Annex 3, Figure 3 and compiled by survey blocks and country in Annex 3, Table 1.

### *9.1 Minke whales*

*i) Distribution*

The Committee noted that although a considerable survey effort was allocated to southern areas southwards to 52EN, the southern limit of the minke whale distribution follows approximately the 1,000 m depth contours from Greenland to the British Isles. The distribution within the area is primarily over continental shelves, but nevertheless the abundance over the deep waters of the Norwegian Sea is considerable. The NASS surveys therefore seem to give a complete picture of the summer distribution of minke whales in the northeast Atlantic.

Compared to earlier surveys, a shift in minke whale distribution was observed in the Barents Sea as few minke whales were seen in the southeastern part off the Kola peninsula in 1995, while this was an area of high density in 1989. Around Iceland the highest densities of minke whales were found over the shelf areas and thus covered by the aerial surveys.

*ii) Abundance*

The overall estimate for the Norwegian survey blocks were 118,000 (CV 0.10); for the Icelandic shipboard surveys 17,900 and the Icelandic aerial survey 55,900 (CV 0.31). This gives a total estimate (corrected by excluding from the shipboard estimates the part that overlaps the aerial survey area) of 184,000 minke whales for the total NASS-95 area (Annex 3, Table 2).

It was noted that minke whale estimates from Icelandic aerial surveys show a great increase from 1987 to 1995, although the total number of sightings is about the same in both years. Although more of the effort in 1995 is in low density areas, so given the same number of sightings, a larger estimate would be expected, the difference is to a large degree a function of different methodology as well as different observers. Thus, reanalysis of the 1987 aerial survey data gives more than twice the estimate obtained by the earlier methods (SC/5/AE/2). Although great fluctuations in estimates are to be expected due to the high variance, the problems involved should be addressed in future aerial surveys.

### *9.2 Fin whales*

*i) Distribution*

The highest densities of fin whales during NASS-95 were found in the area between Iceland and East Greenland and large numbers were also found on the Jan Mayen Ridge and near Spitsbergen. Within the Icelandic survey area, the distribution pattern is similar to previous surveys, although the relative 1995 density is even higher in the Denmark Strait - Irminger Basin than in the 1987 and 1989 surveys.

*ii) Abundance*

The total abundance of fin whales for the areas covered by NASS-95 was 22,800 (CV 0.15). The total estimate for the Norwegian survey area is 3,100 fin whales (CV = 0.25) and for the Icelandic/Faroese survey area 19,700 fin whales (CV=0.17). The estimate for the East Greenland-Iceland stock, 18,900, is the largest to date. In particular, the abundance is considerably higher in the area between E-Greenland and Iceland than in the 1987 and 1989 surveys. In fact the abundance in block 9 alone in 1995 is higher than the total abundance in all blocks from either of the previous surveys. This may reflect a true increase in the stock, while discontinuity in distribution towards the south of the survey area may indicate that the 1995 survey captured the peak of the fin whale migration to these waters better than earlier surveys

### *9.3 Sei whales*

*i) Distribution*

The distribution of sei whales corresponds well with that of the 1987 and 1989 surveys, with consistent low abundances in both Norwegian and Faroese survey areas. However, the 1989 Icelandic survey was conducted somewhat later in the season when the species typically migrates into the area west off Iceland and covered areas further south with large densities of sei whales.

*ii) Abundance*

The total estimate of sei whales from NASS-95 was 9,249 animals (95% confidence interval: 3,700 - 23,116. Although the majority (about 70%) of the 1989 estimate (10,600, CV=0.27) was derived from survey blocks south of the 1995 survey, the two surveys are not inconsistent in the light of the wide confidence limits and difference in timing.

It is unlikely that any of the NASS surveys covered the total distribution of the sei whale stock and the species is known for relatively large between-year variations in abundance in northern waters (Christensen et.al. 1991).

### *9.4 Long-finned pilot whales*

*i) Distribution*

The distribution of ***long-finned pilot whale*** sightings in 1995 is comparable to the distribution observed in the two previous NASS surveys, i.e., the sightings were made south of the ridge Greenland-Iceland-Faroe Islands, with a few stragglers off the Norwegian coast. This indicates that the NASS surveys cover the northernmost areas of pilot whale distribution in the northeast Atlantic.

*ii) Abundance*

The total abundance of pilot whales over all blocks in 1995 is 215,000 animals (CV 0.26).

Previous surveys of long-finned pilot whales had been conducted in 1987 and 1989, and a total estimate of 778,000 (CV 0.29) has been calculated based on 1989 data when the survey had its largest extension. The area surveyed in 1995 covered a similar area to that surveyed in 1987. The total abundance estimate in 1987 was 123,000 (CV 0.29). Excluding blocks in the 1989 survey so that the estimate was comparable to the total estimate from the 1987 data, the 1989 estimate was 191,000 animals (CV 0.33). If the Faroese block B is excluded from the analysis, so that the 1995 estimate is broadly comparable to the 1987 and 1989 estimates, the total abundance estimate in 1995 is 181,440 (CV 0.26). The 1995 estimate is therefore consistent and not significantly different from previous estimates for the area covered.

### *9.5 Non-target species*

The Scientific Committee noted that from a distributional point of view, several other species were also considered by the Working Group on Abundance Estimates, including the NASS-95 distribution of humpback (*Megaptera novaeangliae*), blue (*B. musculus*), sperm (*Physeter macrocephalus*), northern bottlenose (*Hyperoodon ampullatus*) and killer (*Orcinus orca*) whales, harbour porpoises (*Phocoena phocoena*) and small *Delphinidae* (*Lagenorhynchus sp.* and similar species).

### *9.6 Conclusions & recommendations*

The Scientific Committee **concluded** that the updated abundance estimates for the target species as reviewed by the Working Group on Abundance Estimates represented the best available estimates for the stocks concerned.

The Scientific Committee agreed that there would be great value in compiling the results of NASS-95 and the analyses of the sightings data in a single volume for future reference. It was therefore **recommended** that this be done in the context of the NAMMCO scientific publication series and –that the original chairman of the Working Group on Abundance Estimates, Jóhann Sigurjónnson should be assigned the task of coordinating the editing process.

## 10. MONITORING OF STOCK LEVELS AND TRENDS IN STOCK LEVELS OF MARINE MAMMALS IN THE NORTH ATLANTIC

The Chairman noted that at its 5th meeting in Nuuk (February 1995), the Council agreed to the following:

> AIn relation to the importance of the further development of multi-species approaches to the management of marine resources, the Scientific Committee was requested to monitor stock levels and trends in stocks of all marine mammals in the North Atlantic.≅

It was clarified that the purpose of this request was to ensure that data on marine mammals was available for input into multi-species models for management. The Management Committee had suggested that the Scientific Committee present this information annually in the form of a table (*NAMMCO Annual Report 1995:* 47).

At its last meeting, the Scientific Committee had agreed that the Working Group on Abundance Estimates should also be given the task of addressing this request. Øien reported that the Working Group had not had time to discuss the development of a table during its recent meeting in Reykjavik. However, the Secretariat began work compiling the data necessary to include in an overview compilation in table form prior to and during the Scientific Committee meeting, a working draft of which was circulated as SC/5/16.

The Committee discussed the manner in which information on stock levels and trends in stocks would be best presented for the reference of the Council and Management Committee. It was agreed that there would be little value in compiling all information in a single table form, given the differences in survey methodologies and areas on which estimates of abundance levels are based.

In addition, variations in abundance estimates from different periods and areas are not necessarily an indication of trends in stock levels. For example, very little could be concluded at this stage about trends in relation to the target species of the NASS surveys.

Instead, the Committee agreed that updated information on abundance and indications of trends in abundance of stocks of marine mammals in the North Atlantic should be clearly described in a new document for the internal reference of the Council, to replace the List of Priority Species. This document would be entitled Status of Marine Mammals in the North Atlantic and should include those cetacean and pinniped species already contained in the List of Priority Species, as well as other common cetacean species in the NAMMCO area for which distribution and abundance data is also available (fin, sei, humpback, blue, and sperm whales). It was also suggested that it would be useful to include an indication of research needs for each species/stock, as well as references to relevant general review literature and working group reports.

The Scientific Committee **agreed** that the Status of Marine Mammals in the North Atlantic should be further developed by the Secretariat, with the current update of the List of Priority Species as a basis, and in consultation with those members of the Committee who had been assigned the task of updating information on particular species/stocks for the List of Priority Species prior to this meeting. It was also noted that, in the absence of a thorough review of available information on trends in abundance by the Working Group on Abundance Estimates, it was important that the Status document also contain available information on trends, and that it be completed as far as possible in time for the next meeting of the Council.

## 11. DATA AND ADMINISTRATION

### *11.1 Database and data requirements*

The Secretary referred the Committee to document SC/5/6, a report on the status of the databases in the Secretariat, which had been distributed by correspondence to Committee members in July 1996. There were a number of outstanding questions concerning the further development of the catch database in the Secretariat, which had been raised in correspondence with members of the Data Liaison Group established by the Committee at its last meeting, including the question of whether incidental strandings and sightings data, as well as data from sightings surveys should also be compiled at the Secretariat.

As a follow up to the report on the status of databases, the Secretariat had also prepared a draft set of guidelines for the submission of catch data to the Secretariat (SC/5/8 - see Appendix 4), the purpose of which was to establish permanent routines for the format and regular submission of catch data from member countries.

It was agreed that these matters should be further reviewed and discussed through the Data Group, whose role was to advise the Secretariat on data-related matters.

### *11.2 Other matters*

In relation to last year=s recommendation that member countries establish a system for reporting data on by-catches of marine mammals for use in population assessments, and the Council=s request for the Secretariat to investigate the requirements for a standard system in liaison with the Scientific Committee=s Data Group, the Secretariat presented a brief overview of the present status of marine mammal by-catch reporting in NAMMCO member countries, initiatives taken by other international organisations, as well as scientific data requirements for such reporting (SC/5/7 - see Appendix 5).

The Scientific Committee noted that there was at present no systematic reporting of marine mammal by-catches in any NAMMCO member country, although by-catches in Greenland were recorded in the context of the standard catch reporting scheme. The Scientific Committtee agreed that, other than the points noted in item 3 of SC/5/7 (Appendix 5), no further advice could be given on the specific requirements for by-catch data collection until steps were taken by national authorities to establish a system for recording such data.

## 12. PUBLICATIONS

The Chairman referred to the Council=s decision at its last meeting to begin a NAMMCO series of scientific publications. It was subsequently decided that the first edition of the series would be a collection of papers on ringed seals, based on the Scientific Committee=s assessment of this species throughout its range at its 1996 meeting.

Heide-Jørgensen (Greenland) who is co-editing this edition together with Christian Lydersen of the Norwegian Polar Institute in Tromsø, informed the Committee of progress with the editing. Six final papers had been received and were currently being reviewed, while a remaining six contributions would be completed in the near future. It was expected that the publication would be completed by the autumn of 1997.

The Scientific Committee noted in connection with the ringed seal edition that papers dealing with aspects outside the immediate scope of the Working Group=s assessment of ringed seals were also to be included in the edition. It was agreed that the NAMMCO scientific series should not necessarily confine itself to the material reviewed in the context of Working Groups, but should provide a forum for the publication of other papers relevant to an overall review of the subject matter in question, given that appropriate standards for submission and peer review were maintained.

The Secretariat informed the Committee of plans to produce a set of editorial guidelines for authors for use in the editing process for the NAMMCO series. In discussion of copyright matters in relation to distribution of material on the Internet, it was noted that appropriate authorization should be obtained from contributors if NAMMCO publications were in the future to be made available in this context.

The Chairman noted that contributions to the two Working Groups at the present meeting (on food consumption of minke whales, harp and hooded seals in the North Atlantic and sealworm infection), had also provided material which would be useful to publish in the NAMMCO scientific series, as did the results and analyses deriving from the 1995 North Atlantic Sightings Survey (NASS-95) (see also under 7.1.3; 7.2.3 iv) and 9.6 above).

Finally, the Chairman encouraged Scientific Committee members to give some thought to an appropriate title for the NAMMCO scientific publication series.

## 13. BUDGET

The Secretary informed the Committee that although the final budget for 1997 had not yet been formally adopted by the Council, the same level of funding for invited expertise and projects could be expected for 1997 and 1998. Furthermore, it had been proposed that sufficient funding to cover costs earmarked for contract work and editing in connection with the ringed seal publication should be included in the 1997 budget in addition to the sum usually earmarked for the Scientific Committee.

It was noted that there would only be limited funding remaining for further work by the Scientific Committee in 1997 once the costs of invited expertise to the present meeting had been deducted.

## 14. FUTURE WORK PLANS

### *14.1 Scientific Committee*

Noting the fact that the Scientific Committee had now established a tradition of rotating its meetings between member countries, it was agreed that the next meeting of the Scientific Committee should be held in Iceland in 1998. It was also agreed that late February/early March was the most suitable time for most members, but that the precise timing of the next meeting would also depend on the timing of the 1998 Council meeting.

In this connection it was noted that more effort should be made to avoid overlap with meetings of other international organisations normally attended by Scientific Committee members.

### *14.2 Working Groups*

It was noted that the outstanding request to this year=s meeting for an assessment of the status of the Central North Atlantic stock of minke whales would be dealt with through the Working Group on Management Procedures, under the chairmanship of Nils Øien, and that this work would be completed as soon as possible (see 8.6, ii)).

It was further noted that the Working Groups established for the present meeting to deal with the request for advice on food consumption of minke whales, harp seals and hooded seals (SC/5/ME) and sealworm infection (SC/5/SI) had completed their work and it was therefore agreed to dissolve them.

It was agreed that the Working Group on Abundance Estimates should remain in place for the time being to deal with the editing of a review edition on NASS-95 for the NAMMCO publication series (see under 9.6).

The Data Liaison Group would continue to advise the Secretariat on the matters raised under 11.1 above.

## 15. ELECTION OF OFFICERS

Mads Peter Heide-Jørgensen (Greenland) was elected Chairman of the Scientific Committee for the next two years (1997-98). Dorete Bloch (Faroes) was elected Vice-Chairman of the Scientific Committee for the next two years (1997-98).

## 16. ANY OTHER BUSINESS

On behalf of the other members of the Committee, Heide-Jørgensen thanked the retiring Chairman, Tore Haug, for his relaxed and effective handling of the work of the Committee during his term as Chairman, and presented him with a gift as a token of the Committee=s appreciation.

Haug thanked Committee members for their cooperation and hard work during his term as Chairman, and expressed his appreciation to the Secretariat on behalf of the Committee for the organisation of the meeting.

## 17. ADOPTION OF REPORT

A draft report covering a number of the substantive items dealt with by the Committee was reviewed during the meeting. The final report was adopted by correspondence on 10 April 1997.

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Appendix 1

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**WORKING GROUP ON THE ROLE OF MINKE WHALES, HARP SEALS AND HOODED SEALS IN NORTH ATLANTIC ECOSYSTEMS** (SC/5/ME)

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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 of List of Priority Species
7. Role of marine mammals in the marine ecosystem
    - 7.1 Feeding ecology of minke whales, harp seals and hooded seals in the North Atlantic and interactions with fish stocks
    - 7.2 Sealworm infestation
    - 7.3 Other matters
8. Marine mammal stocks - status and advice to the Council
    - 8.1 Long-finned pilot whales
    - 8.2 Killer whales
        - 8.2.1 Update on progress
        - 8.2.2 Future work
    - 8.3 Harp seals
        - 8.3.1 Update on progress
        - 8.3.2 Future work
    - 8.4 Hooded seals
        - 8.4.1 Update on progress
        - 8.4.2 Future work
    - 8.5 Harbour porpoises
    - 8.6 Central North Atlantic minke whales
9. Review of results of NASS-95
10. Monitoring of stock levels and trends in stock levels of marine mammals in the North Atlantic
11. Data and administration
    - 11.1 Database & data requirements
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12. Publications
13. Budget
    - 13.1 Review of funds 1996
    - 13.2 Budgeted funds 1997
14. Future work plans
    - 14.1 Scientific Committee
    - 14.2 Working Groups
    - 14.3 Other matters
15. Election of Officers
    - 15.1 Election of Chairman for 1997/98
    - 15.2 Election of Vice-Chairman for 1997/98
16. Any other business

Appendix 3

# LIST OF DOCUMENTS

***Committee documents***

| | |
|---|---|
| SC/5/1 | List of Participants |
| SC/5/2 | Agenda |
| SC/5/3 | List of Documents |
| SC/5/4 | Report of the Study Group on Long-finned Pilot Whales - ICES C.M.1996/A:6 |
| SC/5/5 | Draft Update of List of Priority Species |
| SC/5/6 | Overview of the current status of databases in the NAMMCO Secretariat (Atli Konráðsson, July 1996) |
| SC/5/7 | Marine mammal by-catch data reporting in NAMMCO member countries (A note by the Secretariat) |
| SC/5/8 | Draft guidelines for the submission of data to the Secretariat |
| SC/5/9 | Report of the Working Group on the role of minke whales, harp seals and hooded seals in North Atlantic ecosystems (SC/5/ME) |
| SC/5/10 | Report of the Working Group on Sealworm Infestation (SC/5/SI) |
| SC/5/11 | Report of the Working Group on Abundance Estimates (SC/5/AE) |
| SC/5/12 | Extract from Report of ASCOBANS Advisory Committee Meeting, 13-15 Nov.1996 |
| SC/5/13 | Report of the Workshop on Harp Seal-Fishery Interactions in the Northwest Atlantic: Toward Research & Management Actions, St. John=s, Newfoundland, Canada, 24-27 February 1997. Canadian Centre for Fisheries Innovation and Memorial University of Newfoundland: I-vi + 41pp. |
| SC/5/14 | Letter from Dorete Bloch regarding National Progress Reports |
| SC/5/15 | T. Gunnlaugsson, Observations on humpback whale distribution and trend in abundance |
| SC/5/16- rev 1 | Table of Abundance Estimates for Marine Mammals in the North Atlantic (working draft) |
| | |
| SC/5/NPR - F | Faroe Islands - Progress Report on Marine Mammal Research in 1996 |
| SC/5/NPR - G | Greenland - Progress Report on Marine Mammal Research in 1995 |
| SC/5/NPR - I | Iceland - Progress Report on Marine Mammal Research in 1996 |
| SC/5/NPR - N | Norway - Progress Report on Marine Mammal Research in 1996 |

***Council documents***

| | |
|---|---|
| NAMMCO/7/8 | Report of the ICES Advisory Committee on Fishery Management (ACFM) and Advisory Committee on Marine Environment (ACME) on Long-finned Pilot Whales (final advice from ICES to NAMMCO). |

Appendix 4

## DRAFT GUIDELINES FOR THE SUBMISSION OF DATA TO THE SECRETARIAT

The current structure of data files in the Secretariat containing catch data and biological information is given in SC/5/6 Table 1. The following are draft guidelines regarding file structure and formats and deadlines for future submission of data to the Secretariat.

### 1. FIELD STRUCTURE IN DATA FILES

***a) Cetacean catch statistics***
*Year* - *month* - *{day}* - *species* - *location* - *no*.

***b) Cetacean individual biological data***
*Year* - *month* - *day* - *location* - *sex* - *length* - *{other}*

***c) Pinniped catch statistics***
*Year* - *{month* - *{day}}* - *species* - *location* - *no.* - *{pups* - *1_ year+}*

Key to field names:

| | |
|---|---|
| *Year* - *month* - *day*: | fields refer to date of catch. |
| *location*: | field refers to location of catch in terms of coordinates or other definitions. |
| *no.*: | total number of animals caught. |
| *other*: | any additional information (e.g. age, reproductive status). |
| *pups*: | no. of animals younger than 1 year at catch. |
| *1_year+:* | no. of animals older than 1 year at catch. |
| *{..}*: | optional field |

### 2. FILE FORMATS

Data files should be submitted in either *Paradox*, *Quatro Pro* or ASCII (in order of preference). As a standard procedure, files should be mailed to the Secretariat on IBM formatted diskettes together with printouts.

### 3. DEADLINES

Data should be submitted to the Secretariat at least once each year and as soon as possible after the end of the hunting season. National institutes identified by the Secretariat as responsible for submission of data are:

**Norway -** Marine Research Institute, Bergen (Nils Øien)
**Iceland -** Marine Research Institute, Reykjavík (Gísli Víkingsson)
**Greenland -** Nature Research Institute , Nuuk (Aqqalu Rosing-Asvid)
**Faroes -** Museum of Natural History, Tórshavn (Dorete Bloch)

Appendix 5

## MARINE MAMMAL BY-CATCH DATA REPORTING IN NAMMCO MEMBER COUNTRIES - A Note by the Secretariat, March 1997

### 1. INTRODUCTION

At its last meeting in 1996, the Scientific Committee noted the importance of obtaining data on the level of by-catches for population assessment. The Council agreed at its Sixth meeting in 1996 to the recommendation from the Scientific Committee that member countries establish a system for reporting data on by-catches, and that the Secretariat be entrusted to investigate the requirements for a standard system of reporting such data, in liaison with the Scientific Committee=s Data Group. As a first step, the following note has been prepared on the current status of by-catch reporting in NAMMCO member countries and discussions in other organsiations, as well some comments on specific data requirements on by-catches.

### 2. CURRENT STATUS OF MARINE MAMMAL BY-CATCH REPORTING

a) NAMMCO member countries have no specific regulations for systematic reporting of marine mammal by-catch in fisheries apart from Greenland, where fishermen are obliged to report all catches of marine mammals. No distinction is made, however, between directed catches and by-catches , other than by-catches of those species subject to IWC aboriginal subsistence quotas.

b) ICES member countries have been urged through an ICES Council resolution from 1994 (Cnl.Res. 1994/4:8) to record all by-catches in the ICES area. A detailed description of data requirements/reporting form has been prepared by the ICES Secretariat (Anon. 1994).

c) It has been formally recommended by the IWC that incidental kills of small cetaceans should be included in National Progress Reports (IWC 1977, p.26). More recently, an IWC Workshop on Mortality of Cetaceans in Passive Nets and Traps recommended that ICES and EC should improve collection coordination of data regarding incidental catches of small cetaceans and should play important roles in facilitating these activities (Perrin et.al.1994).

d) ASCOBANS has expressed interest in cooperating with ICES in the establishment of a by-catch database and in obtaining access to data on fishing effort in the ASCOBANS area.

### 3. DATA REQUIREMENTS

If the database is to be used in the assessment of total by-catch for any population in a given fishery, some points should be considered:

a) *Numbers caught* (e.g. by a sample of vessels) must be registered and at least information on *species, date of catch*, *location*, *gear type* and *sample effort* should be collected. The reliability of data from such reports must be given a special attention. Lien et. al. (1994), for example, compare five different reporting methods and conclude that the numerical estimates of by-catch are at least partly dependent on the methodology used. Furthermore, identification of species is an obvious source of potential error.

b) In the planning stage of any system for registering by-catch, an overview of information regarding *total effort* in the fishery must be available in order to coordinate the registration of total effort and the sample effort in question.

### REFERENCES


Anon. 1994. ICES Environmental Data Reporting Formats, Version 2.2, 1994 November. ICES Envir. Sec.

IWC 1977 Report of the 28th Meeting. *Rep. Int. Whal. Commn 27*, 1977.

Lien, J., G.B. Stenson, S. Carver S. and J. Chardine. 1994. How many did you catch? The effects of methodology on by-catch reports obtained from fishermen. IWC Special Issue 15: 535-540.

Perrin, W.F., G.P. Donovan, and J. Barlow (eds). 1994. *Gillnets and Cetaceans*. International Whaling Commission, Special Issue 15, Cambridge.

**REPORT OF THE SCIENTIFIC COMMITTEE WORKING GROUP ON THE ROLE OF MINKE WHALES, HARP SEALS AND HOODED SEALS IN NORTH ATLANTIC ECOSYSTEMS**

Tromsø, Norway, 10-14 March 1997

## 1.-3. OPENING PROCEDURES

At its Sixth Meeting in Tromsø, March 1996, the Council requested that the Scientific Committee:

*A...focus its attention on the food consumption of three predators in the North Atlantic: the minke whale, the harp seal and the hooded seals, with a particular emphasis on the study of the potential implications for commercially important fish stocks≅*

As a result, the Scientific Committee decided to convene a special Working Group on the Role of Minke Whales, Harp Seals and Hooded Seals in the North Atlantic (SC/5/ME), during the 1997 Scientific Committee meeting. The Working Group was chaired by Gísli Víkingsson (Iceland) and included scientists from Canada, Denmark, Greenland, Iceland, and Norway. A list of participants is given in Appendix 1.

The Agenda for the Working Group as given in Appendix 2 was adopted. Pia Barner Neve (Greenland) and Garry Stenson (Canada) agreed to act as rapporteurs. A list of documents presented and references is given in Appendix 3.

## 4. FEEDING ECOLOGY IN THE NORTH ATLANTIC

### *4.1 North East Atlantic*

#### 4.1.1 Minke whale

SC/5/ME/4 presented current information on the energy requirements, diet composition, and stock size of minke whales *(Balaenoptera acutorostrata)* in northeast Atlantic waters. These were combined to estimate the consumption of various prey species by this stock.

The distribution pattern and abundance estimate were based on a survey conducted in 1995. A total of 85,000 minke whales that feed in coastal waters off northern Norway, in the Barents Sea and around Spitsbergen, were estimated to consume more than 1.8 million tons of prey biomass during the six months from mid-April to mid-October.

This biomass consumed by minke whales was composed of 602,000 tons of krill *(Thysanoessa* spp.), 633,000 tons of herring *(Clupea harengus)*, 142,000 tons of capelin *(Mallotus villosus)*, 256,000 tons of cod *(Gadus morhua)*, 128,000 tons of haddock *(Melanogrammus aeglefinus)*, and 55,000 tons of other fish species, including sand eel (*Ammodytes* sp.) and saithe *(Pollachius virens)*. It was also noted that minke whale diets are subject to year-to-year variations due to changes in the resource base in different feeding areas. Thus, relative distribution of consumption of different prey items is highly dynamic.

Consumption by minke whales may therefore represent an important cause of mortality for some of the prey species. This is indicated, for example, by the fact that the estimated minke whale consumption of herring corresponds to about 70% of the total fishery, or 16% of the estimated spawning stock biomass, of Norwegian spring-spawning herring in the northeast Atlantic in 1995. However, it should be noted that the diet assumed is based upon samples taken during a period (1992-1995) of high herring and low capelin abundance.

The estimate of minke whale consumption was based on an energy model including energy requirements for reproduction, feeding, growth and storage of energy in tissue. Also the energy density of prey species varied seasonally.

Major uncertainties in the model are related to assumptions of minke whale distribution throughout the feeding season. The main strength of the approach was a good abundance estimate and a reasonable assessment of the energy requirements.

#### 4.1.2 Harp seals

Paper SC/5/ME/7 combined data collected in 1990-1996 on harp seal *(Phoca groenlandica)* diet compositions from various areas and seasons in the Barents Sea, with information on the energy density of various prey species. It was possible, under certain assumptions, to estimate the total consumption of various prey items required by harp seals to cover their energy demands. All diet composition data were based on reconstructed prey biomass, and adjustments were made for differences in digestibility of crustaceans and fish. The number of seals belonging to different age and sex groups was calculated, and then their monthly food requirements were modelled.

Under the assumptions of a variable basal metabolic rate (BMR) throughout the year, and a field metabolic rate (FMR) of 2 x BMR, the estimated consumption by harp seals of crustaceans was 428,200 tons, capelin 258,200 tons (in 1992 when capelin stocks were high), polar cod *(Boreogadus saida)*, 212 500 tons, herring *(Clupea harengus)* 69,600 tons, cod *(Gadus morhua)*, 32,200 tons and Avarious fish≅ 142,300 tons.

The total food consumption of the Barents Sea harp seal stock (assumed to comprise 700,000 seals, including 100,000 pups) was estimated to be in the range of 1.14 - 1.61 million tons (depending on choice of input parameters) when capelin *(Mallotus villosus)* is abundant in the Barents Sea ecosystem. When capelin stocks in the Barents Sea are low, the estimated total food consumption increased slightly, to values ranging between 1.25 - 1.74 million tons. According to the model the largest quantities of food were consumed in the period June-September.

When the capelin stock was at a very low level (as in the period 1993-1996), consumption of capelin seemed to be replaced by an increased consumption of other species, particularly polar cod (from 16.9-18.6 % to 25.5-26.1%), followed by other gadoids, Avarious fish≅, herring and crustaceans. Using the same assumptions as above, the harp seal consumption of polar cod increased by 113,900 tons, other gadoids (cod, saithe and haddock) by 80,200 tons, various fish by 76,500 tons, herring by 61,300 tons, and crustaceans by 29,100 tons.

The food consumption estimates are sensitive to the model assumptions. The most critical parameter for the total consumption estimates examined in the model was the choice of the multiplier ("a") for predictions of field metabolic rate from basal metabolic rate FMR = a x BMR. When ≅a≅ was increased from 2 to 3, the estimated food consumption increased approximately 40%. Stenson et al. (1995) estimated an increased food consumption of 25% when they increased Aa≅ from 2 to 2.5. The consumption estimates based on the lowest FMR (Aa≅ = 2) in SC/5/ME/7 are similar to estimates based on the monitored energy expenditures of immature harp seals in captivity throughout the year (Nordøy et al. 1995).
The consumption estimates showed little variation by changing procedure for calculating basal metabolic rate (BMR) in the model (annual average BMR or monthly changes in BMR).

#### 4.1.3 Cod

SC/5/ME/11 describes the diet of cod in the Barents Sea in the period 1984-1995, based on consumption calculations made by Bogstad and Mehl (1996). The total annual consumption by cod in the Barents Sea varied between 5 and 7 million tons in the period 1992-1995, i.e. the consumption by cod is about twice that of harp seals and minke whales combined. The diet is dominated by fish, with capelin as the most important prey. The consumption estimates are based on stomach content data and a model of the gastric evacuation rate. Consumption is calculated separately for three areas, each half-year and cod age group. The composition of the diet varies considerably between years, corresponding to the fluctuations in the prey (particularly capelin) stock size. For some years and prey species, the calculated consumption is considerably higher than the prey stock estimate. The consumption per cod is also quite variable.

## *4.2 Central North Atlantic*

### 4.2.1 Minke whales

Paper SC/5/ME/5 summarises the available data on stomach contents of minke whales in Icelandic waters. 58 animals, mostly from June/July 1977-78 were examined, of which 44.8 % contained fish only, 24.1 % krill only and 29.3 % a mixture of the two. The identified fish species were capelin, sand eel and Atlantic cod. Calculations based on a population estimate from the NASS-87 and NASS-89 surveys, migration patterns and estimated energy requirements indicate that minke whales consume around 391,000 tons in Icelandic and adjacent waters (approximately ICES 5a division), of which 198,000 tons are fish (Sigurjónsson and Víkingsson 1995) . The Working Group noted that the diet assumptions are based upon low sample sizes and a simple classifications system of the prey items found in the stomachs.

### 4.2.2 Harp seals

SC/5/ME/8 presented information on diet of harp seals from 1987-1992. The material was collected in the Greenland Sea pack ice (the West Ice) during spring and early summer. The majority of the harp seal stomachs were empty in all sampling periods, but intestinal contents were found in most of the seals. The harp seal diet was totally dominated by pelagic amphipods *(Themisto* sp.), but krill *(Thysanoessa* sp.) and polar cod *(Boreogadus saida)* were also eaten quite frequently.

Gray (1889) reported that stomachs of adult harp seals in the Greenland Sea contained *Themisto libellula* and krill, while Surkov (1960) reported *Themisto* sp. in harp seal stomachs and crustacean remains in faecal masses on the ice in the Jan Mayen area during spring and July. *Themisto* sp. was the dominant prey of young (< 1 year) harp seals in the Greenland Sea in April 1995 (Haug et al. 1996). Polar cod also occurred frequently in the harp seal intestines in some of the sampling periods in this study, which is consistent with previous observations made during spring and summer in coastal areas of eastern Greenland (Pedersen 1930; Rasmussen 1957).

Harp seals collected in the period February-May in coastal areas of northern Iceland had a diet comprised mainly of sandeels *Ammodytes* sp., codfishes (*Gadidae*), capelin *(Mallotus villosus)* and other fish species. Crustaceans (including amphipods and krill) and other invertebrates were also present (Hauksson and Bogason 1995a).

### 4.2.3 Hooded Seals

Paper SC/5/ME/8 presented information on the diet of hooded seals *(Cystophora cristata)* collected in May and June 1992 and 1994 during Soviet/Russian commercial sealing in Greenland Sea pack ice. The majority of the hooded seal stomachs were empty in all sampling periods, but intestinal contents were found in most of the seals. The hooded seals had mainly been feeding on squid *(Gonatus fabricii)*, which occurred most frequently in the intestines. It also dominated the biomass in the few stomachs with contents. Polar cod also occurred frequently in most of the periods, while crustaceans, such as amphipods and krill, occurred sporadically.

Little additional information is available concerning hooded seal diets in the Greenland Sea. Arsenjev et al. (1973) reported that the hooded seal diet in the Greenland Sea consisted mainly of squid and to a lesser extent fish, such as redfish, codfishes and others.

Pelagic amphipods *(Themisto libellula)* dominated the hooded seal pup diet after weaning (April) in the Greenland Sea (Haug et al. 1996). As in the present analyses (SC/5/ME/8), most hooded seal stomachs examined by local hunters in Southeast Greenland were empty in July and August (Kapel 1982;1995). In those with contents redfish *(Sebastes* sp.) dominated. The dominance of the squid *(G. fabricii)* and the frequent occurrence of polar cod in the hooded seal diet (SC/5/ME/8) resembles stomach content analysis of young hooded seals made in Southeast Greenland in September when squid dominated the diet, followed by shrimp *(Pandalus* sp.), polar cod and redfish (Kapel 1995*)*.

In the coastal waters of northern Iceland from April to October, hooded seals were reported to feed mainly on redfish, cod and various other fishes. Shrimp and squid *(Todarodes sagittatus)* were also eaten (Hauksson and Bogason 1995b).

Recent satellite tracking data have shown that hooded seal migrate between breeding and moult from the pack ice areas off eastern Greenland to the continental shelf edges off the Faroe Islands and northern Ireland, and to areas in the Norwegian Sea (Folkow and Blix 1995; Folkow et al. 1996). After moult hooded seals perform excursions which last for approximately 3-7 weeks to the waters off the Faroe Islands, the Irminger Sea, north/northeast of Iceland, areas in the Norwegian Sea and along the continental shelf edge from Norway to Bear Island.

Evidence of hooded seal feeding habits in these areas are lacking. In order to improve current knowledge on the feeding habits of hooded seals, stomach and intestines should be sampled in the areas where the seals are observed to occur for longer periods.

### *4.3 Northwest Atlantic*

#### 4.3.1 Minke whales

SC/5/ME/15 presented a review of earlier published results on the diet of minke whales in Greenland together with information reported by local hunters in Greenland through the Greenland Home Rule reporting system. Previous information on the feeding of minke whales highlights the importance of capelin as the most important prey species, making up about 70 % of the items found in the stomachs. Other identified food items recorded are Atlantic cod (*Gadus morhua*), polar cod (*Boreogadaus saida*), Greenland cod (*Gadus ogac*), and Atlantic catfish (*Anarhichas lupus*), herring , sand eel (*Ammodytes* sp.). Amphipoda (*Themisto sp.*), euphausiacea (*Thysanoessa sp.*), decapoda (*Pandalus sp.*) and pteropods have also been reported. Minke whales in Greenland appear to have a flexible feeding pattern.

A review of the available information on the diet, distribution and abundance of minke whales in Atlantic Canada was presented in SC/5/ME/6. The most comprehensive information on diet was collected prior to 1972 and indicated that capelin was the primary prey. Other species such as squid (*Illex illecebrosus*), salmon (*Salmo salar*), herring, cod, euphausiids and copepods were also eaten. Examination of a small number (n=10) of stomachs from minkes caught in fishing nets indicate that the whales had been feeding exclusively on capelin. There is no information on the diet of minke whales in the Gulf of St. Lawrence. A study of whales in one Newfoundland bay during the early 1980s (Piatt et al. 1989) estimated that humpback, fin and minke whales took less than 1% of the total capelin biomass in the area. Of this, minke whales accounted for approximately 10%.

There are no current estimates of minke whale abundance in Canadian waters and the seasonal distribution is unknown. However, a preliminary estimate of prey consumption assuming a population of 6,000 and seasonal movements between Newfoundland and the Gulf of St. Lawrence suggests that minke whale consumption is relatively low in comparison to harp seal consumption. The amount of capelin consumed may be greater than that taken by hooded, grey or harbour seals in the area, but this estimate was considered to be illustrative and not appropriate for detailed comparisons.

#### 4.3.2 Harp Seals

Paper SC/5/ME/9 presented information on results of stomach contents analysis of material collected in West Greenland waters in the period 1986-93 compared with published data and information from local hunters. The diet of harp seals feeding in this region is available but consists mainly of pelagic crustaceans (*Thysanoessa ssp.* and *Themisto libellula*) and small fish species like capelin (*Mallotus villosus*), sand eel (*Ammodytes ssp*.), polar cod (*Boreogadus saida*) and Arctic cod (*Aectogadus glacialis*). Species of importance for commercial fisheries in Greenland, such as northern shrimp (*Pandalus borealis*), Atlantic cod (*Gadus morhua*), and Greenland halibut (*Reinhardtius hippoglossoides*) play a minor role in the diet of harp seals in this area.

Using information on distribution of catches and recoveries of tagged seals, an attempt to calculate the relative importance of various prey items of harp seals during their stay in coastal West Greenland was presented. It was concluded that about 1/3 of the food was capelin, 1/4 polar cod and 1/4 euphasiids or amphipods. Cod, shrimp and Greenland halibut each constituted 1-2 % of the food eaten. However, even at this low level, consumption by harp and hooded seals of these three prey species may well be of the same order as the commercial fishery in this region.

The estimates of consumption are sensitive to the assumed number of harp seals in West Greenland throughout the year.

Estimates of the consumption of Atlantic cod, capelin, and *Boreogadus* by harp seals off the coast of Newfoundland and in the Gulf of St. Lawrence were presented in Stenson et al. (1995). SC/5/ME/10 provides an update of the model used previously to estimate consumption of all prey species in Atlantic Canada from 1990-96. It also provides estimates of consumption by grey, harbour and hooded seals for comparison.

Harp seals were the most important pinniped predator in the northern Gulf and NAFO areas 2J3KL. They were estimated to have consumed over 150,000 tons of Atlantic cod, 1.1 million tons of capelin, 600,000 tons of *Boreogadus*, 130,000 tons of Greenland halibut, 107,000 tons of redfish and 104.000 tons of herring in 1996.The amount of cod consumed was not sensitive to the assumption concerning the proportion of time spent in near shore or offshore areas of Newfoundland, but changes in this assumption will affect estimates of the other species, particularly capelin, herring and *Boreogadus*. Although the total amount of prey consumed by harp seals in Atlantic Canada is large, most are not commercial species or taken prior to recruitment to the fishery.

There were several differences in the model presented in SC/5/ME/10 when compared with that found in Stenson et al. (1995). The major differences were related to the use of a population model which assumes that pup mortality is greater than that of older seals and incorporating seasonal and geographic variation in the diet of seals off Newfoundland. The proportion of time spent in the Gulf of St. Lawrence and off Newfoundland was also corrected from the earlier model. The resulting estimates were similar to those presented in Stenson et al. (1995) for the same time period, although the proportion taken off Newfoundland is greater while that taken in the Gulf is less.

There is a considerable amount of information available on harp seals in the Northwest Atlantic, particularly on population size, and energy requirements. There is also extensive data on geographical and seasonal variations in the diet of harp seals off Newfoundland although there is less information for offshore areas and in the Gulf. The greatest source of uncertainty in the estimates of consumption are related to the limited information available on the seasonal distribution of harp seals and potential spacial and temporal variations in the diet. Current studies on the movements of seals using satellite telemetry will increase our understanding of the distribution of harp seals and improve the estimates of consumption.

### 4.3.2 Hooded Seals

Paper SC/5/ME/9 also presented information on the results of stomach contents analysis of material from hooded seals collected in Greenland waters in the period 1986-93 and information from hunters from 1970-83. Variation in the diet of hooded seals is less well documented than the harp seal, but in addition to the species also taken by harp seals, larger demersal fishes such as Greenland halibut, redfish (*Sebastes ssp.*), cod and wolffish (*Anarhichas minor*) are apparently important prey items.

SC/5/ME/10 presents estimates of prey consumption of hooded seals in Atlantic Canada. Total abundance was estimated using a Leslie matrix model and recent data on reproductive rates. Based on estimates of pup production off Newfoundland and in the Gulf of St. Lawrence, the population was assumed to be increasing at 5% per year in this area. Greenland halibut was the major prey of hooded seals in offshore areas, followed by witch flounder, squid (*Gonatus*), and Atlantic cod. Greenland halibut and redfish were the main prey in inshore areas. No information was available on the diet in the Gulf and it was assumed that it was the same as that observed in near shore areas of Newfoundland. Considering the small population present in the Gulf, changes in this assumption will affect the estimates of consumption in the northern Gulf but will have little influence on the estimates of total consumption.

Hooded seals were estimated to have consumed approximately 129,000 tons of Greenland halibut, 36,000 tons of Atlantic cod and 19,000 tons of redfish in 1996. Almost all of the prey consumed were from NAFO division 2J3KL. However, these estimates are based upon a limited number of samples of hooded seal diet.

The greatest sources of uncertainty in the consumption estimates are associated with the estimates of abundance and seasonal distribution. The model assumes that the change in pup production between 1984 and 1990 represents an actual increase in the area and not a temporary influx of females from Davis Strait. It is also assumed that Davis Strait hooded seals do not enter the area. There is also uncertainty associated with the seasonal distribution of hooded seals. While satellite telemetry has provided information on the movements of seals during the spring, little is known about their distribution during the fall and winter.

## 5. INTERACTIONS BETWEEN MARINE MAMMALS (MINKE WHALES, HARP AND HOODED SEALS) AND COMMERCIALLY IMPORTANT FISH STOCKS - MULTISPECIES MODELLING

### *5.1 Northeast Atlantic*

Two papers describing multispecies models incorporating fish and marine mammal stocks in Northeast Atlantic were presented.

SC/5/ME/11 describes how multispecies interactions between minke whales, harp seals, herring, capelin and cod in the Barents Sea are modelled in the multispecies model MULTSPEC (Bogstad et al. in press). The model is divided into seven areas, and the species included are also structured by age, sex and length (fish only). A one-month time step is used. In the model, minke whales and harp seals are predators on cod, capelin and herring. Cod prey on capelin, herring and young cod (cannibalism), while herring is a predator on capelin larvae. The feeding, growth, fertility and natural mortality rates of minke whales and harp seals all assumed to be constant. The feeding and growth rates of cod are affected by the abundance of prey, while the growth of herring and capelin depends on the abundance of these two species combined.

MULTSPEC was used to study the effects of varying:

i) the stock size of harp seals and minke whales;
ii) the food preferences of harp seals and minke whales; and
iii) the food preferences of cod.

This was done by running the model for a period of 20 years. A reference run, resulting in variations in the biomass of cod, herring and capelin within the range observed for the period where stock estimates are available, was decided upon. A fixed harvesting rate for fish and marine mammals was assumed throughout the period. In the reference run, the catches of marine mammals are set so that the marine mammal populations stay approximately constant.

The main effects can be summarized as follows:

The herring stock increased as predation from marine mammals decreased. With prey preference as in the reference run, the herring stock was much more sensitive to changes in the minke whale stock than to changes in the harp seal stock. The quantity of herring consumed by whales and seals in the Barents Sea was moderate or negligible compared to the total herring stock biomass. The reason why the herring stock was so sensitive to changes in the whale stock is that predation reduced the number of recruits to the mature stock by an amount which is not negligible, and this had both an immediate effect on the total stock and a long-term effect through the spawning stock-recruitment relationship.

The development of the capelin stock was mainly determined by changes in the herring and cod stocks. The effect of changes in these stocks on capelin generally went in the opposite direction to effects from changes in marine mammal predation on capelin. This resulted in an increase in the capelin stock when the minke whale stock increased, and *vice versa*. Since herring was less sensitive to changes in the seal stock than to changes in the minke whale stock, and since predation on capelin from seals was high, an increase in the seal stock lead to a decrease in the capelin stock, and *vice versa*.

Generally, the cod stock increased or decreased when marine mammal stocks decreased or increased, as expected. However, because of the strong cod-capelin interactions, resulting in a tendency to cyclic variations in the two stock trajectories, the changes in the cod stock in some years was in a direction opposite to the one expected when compared to the reference run.

Decreasing the preference herring by cod had much greater effects than changing some of the marine mammal preferences, and even more dramatic effects than removing both marine mammal stocks from the system. In these runs, the herring stock increased above historical levels, with resulting detrimental effects on the capelin stock. The cod stock also decreased due to low capelin stock. An increasing minke whale stock had the greatest affect on the herring stock, while an increased harp seal stock mainly affected the capelin and herring stocks.

Considering the importance of polar cod to harp seals and possibly cod, including polar cod into the model may affect the interactions observed. It was also noted that the prey preferences in the model remained constant throughout the year. Given the reported changes in the prey selection by harp seals in the Barents Sea, it is important to consider the potential effect seasonal differences in prey selection may have on the model.

The MULTSPEC model was designed to describe fish/fish interactions. Although marine mammals have been included, their impact is through removal of fish. The model allows for the inclusion of an impact of fish stock size on the reproductive rates and growth of marine mammals, but such runs have not been made. Inclusion of such effects may provide a more realistic view of interactions among the species.
.......

SC/5/ME/12 investigated the effect of tuning the Revised Management Procedure (RMP) for minke whales from the current level (with a stock target of 72% of carrying capacity - k) to one with a lower abundance (60% of k) on fish stocks in the Barents and Norwegian Seas. A number of scenarios were simulated and the results analysed by regression methods. Four species were included in the model: cod, capelin, herring and minke whales. The fish populations were age and length distributed, while the minke whale was age and sex distributed. The time step was one month, and two areas (Barents and Norwegian Sea) were included.

The model assumes a food-web with minke whales as the apex predator, consuming herring, capelin and cod. Cod consume cod, herring and capelin, while herring prey on capelin. A non-linear function for minke whale prey preference is used. Minke whales may forage on plankton and fish other than cod, capelin or herring, and are thus modelled as having carrying capacity and demographic parameters independent of the status of the fish stocks in the model.

A constant fishery model was assumed for cod and herring, while capelin was managed using a fixed target spawning stock. Minke whales were managed according to the RMP. Fish recruitment and survey indices of minke whales were modelled stochastically. The model, run over a 100 year period, simulated 27 scenarios spanning 9 experimental factors, at three levels each. The primary study variable was the tuning level of the RMP, and the response variables are cod and herring catches and mortality caused by whale predation. The response variables were average over the last 90 years of the period.

Assuming 100,000 minke whales and MSYR between 1% and 2%, the main effect of changing the RMP target from 72 % to 60 % was an increase of some 14% in the cod catches. Mean mortality rate for cod caused by minke whales decreased from 0.2 to 0.1 and the mean yearly catch of whales was increased from approximately 270 animals to around 490 animals. For herring, no clear main effect was found on catch or mortality rate.

It was difficult for the Working Group to interpret the results of the model because of questions concerning the validity of the parameters used. The carrying capacity for the minke whale appears to have been set too high and the reproductive capacity (MSYR) too low. More relevant results might have been obtained with a lower carrying capacity and higher reproductive capacity.

Although indirect effects on the stock size of capelin and herring due to changes in marine mammal abundance were observed in the MULTSPEC model of the Barents Sea (SC/5/ME/11) and the model presented for Iceland (SC/5/ME/13), they were not observed in the model presented in SC/5/ME/12. This may be due to the different methods used or a result of the parameters chosen. The model should be run using a different set of parameters to determine if indirect effects are present.

In this model, the population dynamics of minke whales were assumed to be independent of prey availability. If prey availability is a limiting factor, the consumption might not be independent of stock level, as modelled.

The fish-fish interactions are not well estimated, particularly predation of herring on capelin and cannibalism in cod. The net effect of increased whaling on cod catches may be less clear-cut, particularly when the whale stock is at lower levels, if predation of capelin by herring in the Barents Sea or the amount of cannibalism by cod is greater than assumed in the current model.

In the general discussion that followed on the two models presented for the Northeast Atlantic it was noted that neither model included size selectivity in terms of the amount of fish taken by marine mammals. Both models assumed a constant size selection pattern. Data exists to estimate the age selectivity from the diet samples and it was felt that these data should be incorporated into the models. It was also noted that different models of the cod/capelin/herring dynamics are used and it is therefore difficult to determine whether the differences in estimates with varying marine mammal abundance are due to the way in which the fish species are modelled rather than how the marine mammals are included.

### *5.2 Central North Atlantic*

A model which explores potential interactions between several marine mammal species off Iceland and commercially important stocks that constitute their principal prey was presented in SC/5/ME/13. The analysis included three whale species - fin whale (*Balaenoptera physalus)*, minke whale (*Balaenoptera acutorostrata)* and humpback whale (*Megaptera novaeangliae*), two seal species - harbour seal (*Phoca vitulina)* and grey seal (*Halichoerus grypus)*, two fish species - Atlantic cod and capelin, and shrimp (*Pandalus borealis*). The inclusion of seals in the computations is a new and important addition to earlier models (Stefánsson et al., 1994; Stefánsson et al., 1995; Baldursson et al., 1996) for the area. In this model, cod act as both prey for the marine mammals, and as predator on capelin, shrimp, and young cod (cannibalism).

A single-species model of different harvest regimes of the Icelandic cod stock has been combined with a crude multispecies model to study the potential impacts of various developments of the marine mammal stocks on capelin and cod stocks. The model was run using a variety of assumptions regarding stock sizes, food preference, potential rates of increase and harvesting strategies. Simple aggregate population models were used to describe the marine mammal stocks, and the population and fisheries dynamics for shrimp and capelin were modelled using simple biomass-production models. Thus, only aggregates such as total, recruiting or adult numbers or biomass were considered for these species, as opposed to the fully age-class based cod model.

The impact of the five species of marine mammals on the development of the cod stock is uncertain. However, in the base run natural mortality from predation was estimated to be about twice that due to cannibalism and thus may be a major portion of natural mortality on the younger ages. Given the limited data on which the estimates of marine mammal consumption are based, it is important to improve understanding of the feeding habits of whales and seals in the area.

The main advantage of the approach used is model simplicity and thus clarity in terms of which factors affect which results. The simplicity comes at the expense of a lack of internal consistency, since each species group is modelled according to its own simplified approach and there is no possibility of examining the importance of spacial and temporal effects.

In the discussions that followed it was noted that although the residual natural mortality is unknown, it would have to be extremely large to change the effect of reducing whales on cod yield. However, the decrease in predation mortality which may be expected by reducing the numbers of marine mammal predators was compensated, to some extent, by increased cannibalism.

Recent information obtained from satellite telemetry and observed catches indicate that harp and hooded seals are seasonal migrants to Icelandic waters. They may provide an additional source of mortality on cod. It will be possible to estimate the level of predation by harp and hooded seals when more information on their movements and diet are obtained.

Paper SC/5/ME/14 described a statistically-based multispecies model framework, based on defining many stock components corresponding to areas, maturity stages, length and age groups. This approach allows for the possibility of using many different data sources in order to obtain a consistent set of parameters describing e.g. growth, migration, consumption and fishing. The main drawback of the methodology lies in the complexity and inherent difficulty in obtaining the adequately disaggregated data. The main advantage lies in the possibility of evaluating the effects of including spatial information and overlap as well as comparing information in different data sources.

This approach is similar to that described SC/5/ME/11. Although they provide a better understanding of the interactions between the components of the ecosystem, they are difficult to parameterize. The Working Group encourages this approach.

### *5.3 Northwest Atlantic*

No models designed to assess the impact of the estimated harp or hooded seal consumption on commercial fish stocks in the Northwest Atlantic were presented. However, the Working Group was informed that work is currently underway to incorporate harp seal consumption into a sequential population analysis for NAFO Division 2J3KL cod (>Northern Cod=). The approach will be similar to that described in Mohn and Bowen (in press), which presents a two-species model (grey seals and Atlantic cod) describing the potential impact of seals on Eastern Scotian Shelf cod.

The difficulty of constructing multispecies models for the Northwest Atlantic was addressed by the Workshop on Interactions between Harp Seals and Commercial Fish in the Northwest Atlantic (see 5.4 below)..

### *5.4 Report of the Workshop on Harp Seal-Fishery Interactions in the Northwest Atlantic*

Paper SC/5/13 presented the report from the Workshop on Harp Seal- Fishery Interactions held at Memorial University, St. Johns, Canada from 24 to 27 February 1997. The following is a summary of the main conclusions of the Workshop.

*Population Size and Trends*

The Workshop concluded that harp seal numbers in the Northwest Atlantic have increased since 1978, and that the best estimate of the 1994 total population size is around 4.5 million animals (although the precise size depends on what is assumed about the mortality of young animals). Animals are now growing more slowly, and the pregnancy rate is lower, than in the 1980s. These effects are expected when food becomes more difficult to find.

*Harp Seal Diet*
The diet of harp seals in the near shore waters of the Labrador-Newfoundland shelf is dominated by Arctic cod (*Boreogadus saida)*, with some capelin and herring. In offshore waters the most important species are capelin and flatfish (mostly Greenland halibut). In both areas, Atlantic cod is a small, but apparently consistent, part of the diet. The proportion of Atlantic cod in the diet of harp seals does not appear to have declined in recent years, but this needs to be examined more carefully.

*Effects on Commercial Fisheries*
The Workshop could not assess whether or not harp seals were affecting commercial fish stocks - and Atlantic cod, in particular - on the Labrador-Newfoundland shelf. This was because there is an urgent need for an estimate of the size of the cod stock in both inshore and offshore areas, and for an assessment of the amounts of cod which are being taken by the other important predators (such as Greenland halibut, whales, and seabirds). When this information is available, it will be possible to analyse the effect of predation on the Atlantic cod stock.

*Recommendations*
A number of specific recommendations were made by the Workshop. The more general recommendations, summarised in order of priority, were:

1. There is an urgent need for an accurate estimate of the distribution and absolute abundance of young cod, in age-classes 0,1 and 2, in the inshore and offshore waters of NAFO divisions 2J, 3K and 3L.

2. The consumption of fish by harp seals in NAFO divisions 2J, 3K and 3L needs to be placed in context. There is therefore an urgent need for better estimates of the diet and consumption of fish by other predators in this ecosystem.

3. If the impact of higher predators on cod stocks is to be assessed, there is a need to extend the single species models which have been used to assess the status of cod stocks to include the effects of other predators.

4. Monitoring of the diet and pregnancy rate of harp seals should continue. More studies of the distribution of adult and young harp seals in NAFO divisions 2J, 3K and 3L using satellite transmitters are needed to refine the existing estimates of how much time is spent in the inshore and offshore waters of these divisions. Results from these studies should then be used to direct the sampling of harp seals for diet studies.

5. Existing information on the proportion of cod in the diet of harp seals in NAFO divisions 2J, 3K and 3L should be reanalysed to determine the statistical power of these data to detect trends over time, and to estimate the probability that this proportion has fallen to lower levels in recent years.

6. The model used to estimate abundance, trends in abundance, and replacement yields for harp seals in the Northwest Atlantic should explicitly incorporate variance in all of the inputs (i.e., catch at age, age-specific pregnancy, and pup production), by maximizing the combined likelihood over all available data. The sensitivity of this model to assumptions regarding longevity should also be investigated.

The Workshop also recognized the fundamental importance of capelin in the Newfoundland-Labrador shelf ecosystem.

### *5.5 Theoretical consideration of multispecies models*

In a discussion of the theoretical aspects of multispecies models, the Working Group noted that when ICES takes into account the results of multispecies models they usually only incorporate interactions among fish species. Marine mammal consumption is usually considered part of natural mortality in the normal assessments. However, in Iceland marine mammals have recently been incorporated into models used to understand the impact of long-term management strategies.

Because marine mammal stocks vary slowly, they have little effect on short term management goals which are more likely to be affected by fish/fish interactions. For long-term strategies, however, models should attempt to include long-term effects such as marine mammals.

A number of specific questions were considered by the Working Group.

*i) What are the potential uses of multispecies models?*
Multispecies models provide insight into a number of aspects of the ecosystem and the way in which various components may interact. As such they can be used to:

- improve our understanding of how different factors influence the ecosystem;
- identify gaps in knowledge;
- identify which uncertainties are important to answer the questions we pose and which are not;
- provide an indication of where research efforts should be directed to improve management advice;
- assess the possible effects of a given management strategy.

*ii) What is the current state of multispecies modelling in the North Atlantic*?
There are efforts to model multispecies interactions in the Barents and Norwegian Seas and Icelandic areas. The output of these models incorporating fish/fish interactions are being used in management. However, models explicitly incorporating marine mammals are not routinely used. The available models provide a general impression of interactions and illustrate the range of effects which may occur. However, it should be realised that the models are designed to answer questions concerning the impact of various components of the ecosystem on fish, particularly cod. They do not include marine mammal/marine mammal interactions nor the potential effect of the prey on the apex predator. The models described in SC/5/ME/11 and SC/5/ME /14 will, in theory, allow this to be modelled but there is presently a lack of the appropriate data.

*iii) What conclusions can be drawn from the results of the available models?*
It must be remembered that models are designed to answer specific questions and extreme care should be taken before extending the interpretations to answer questions that were not specifically posed when constructing the model. For example, comparing the yield in two runs with different scenarios of whale abundance is not quite the same as estimating the impact of changing the abundance of whales with the associated uncertainties. This may be addressed if the model is constructed with the question in mind. One approach may be to include a wide range of scenarios similar to that outlined in SC/5/ME/12.

Including marine mammals in the current multispecies models provides a more realistic estimate of the uncertainty in predictions of fish abundance.

*iv) What should be done to improve the models?*
Uncertainty in the parameters (e.g. stock estimates, food preferences, migration) should be included in the models to provide a realistic estimate of total uncertainty.

The factors influencing migration or prey selection are poorly understood. A good understanding of these processes is important and should be incorporated into the models.

Models should be constructed on the appropriate spatial and temporal scale for the various components.

## 6. FUTURE WORK - RECOMMENDATIONS

The results of studies presented to the Working Group indicate that minke whales, harp and hooded seals may have substantial direct and/or indirect effects on commercial fish stocks. To better understand these effects, the Working Group **recommended** the following:

1) For each species, knowledge should be improved on seasonal, annual and spatial variations in:
- abundance
- distribution
- diet
- energy requirements
- prey abundance

Knowledge on each of these factors varies for areas and species. The degree of knowledge for each has been noted within the report and should be considered when developing specific research plans.

2) The understanding of prey selectivity and responses to changes in prey abundance by these predators should be improved. Little is known about these processes at the present time.

3) Estimates of consumption by other important predators should be obtained and the degree of potential competition assessed.

4) Multispecies models should be improved by:
- incorporating uncertainty in the parameters (e.g. stock estimates, food preferences, migration) to provide a realistic estimate of the total uncertainty;
- incorporating variations in migration and prey selection. An understanding of these processes is important, but they are not understood at present;
- constructing them on the appropriate spacial and temporal scale for the various components.

5) Efforts to construct multispecies models in the Northwest Atlantic should be encouraged.

## 7. ADOPTION OF REPORT

The report was adopted on 13 March 1997.

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# AGENDA

1. Opening remarks

2. Adoption of Agenda

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4. Feeding ecology of minke whales, harp seals and hooded seals in the North Atlantic
   - 4.1 NE-Atlantic
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5. Interactions between marine mammals (minke whales, harp and hooded seals) and commercially important fish stocks - Multispecies modelling

5.1 NE-Atlantic

5.2 Central N-Atlantic

5.3 NW-Atlantic

5.4 Report of the Workshop on Harp Seal/Fisheries Interactions, St. John=s, February 1997.

5.5 Theoretical consideration of multispecies models

6. Future work - Recommendations

7. Any other business

8. Adoption of report

## LIST OF DOCUMENTS

Working Group documents

| | |
|---|---|
| SC/5/ME/4 | Lars P. Folkow, Tore Haug, Kjell.T. Nilssen, and Erling S. Nordøy**,** Estimated food consumption of minke whales in Northeast Atlantic waters in 1992-1995 |
| SC/5/ME/5 | Jóhann Sigurjónsson and Anton Galan, Some information on stomach contents of minke whales (*Balaenoptera acutorostrata*) in Icelandic waters. |
| SC/5/ME/6 | J. Lien, B. Sjare, M.O. Hammill and G. Stenson, Diet and Prey Consumption by Minke Whales in the Northwest Atlantic: A Review |
| SC/5/ME/7 | Kjell.T. Nilssen, Ole Petter Pedersen, Lars P. Folkow & Tore Haug. Food consumption of Barents Sea harp seals. |
| SC/5/ME/8 | Vladimir Potelov, Kjell T.Nilssen, Vladislav Svetochev & Tore Haug, Feeding habits of harp (*Phoca groenlandica*) and hooded seals (*Cystophora cristata*) during moult (April-June) in the Greenland Sea |
| SC/5/ME/9 | Finn O. Kapel, Feeding habits of harp and hooded seals in Greenland waters |
| SC/5/ME/10 | M.O. Hammill & G.B. Stenson, Estimated prey consumption by Harp seals (*Phoca groenlandica*), Grey seals (*Halichoerus grypus*), Harbour seals (*Phoca vitulina*) and hooded seals (*Cystophora cristata*) in the Northwest Atlantic. |
| SC/5/ME/11 | Bjarte Bogstad, Multispecies interactions between minke whales, harp seals, herring, capelin and cod in the Barents Sea |
| SC/5/ME/12 | Tore Schweder, Einar Hatlebakk and Gro S. Hagen, On the effect of whaling on other fisheries: Scenario experiments of the Barents- and Norwegian Sea |
| SC/5/ME/13 | Gunnar Stefánsson, Erlingur Hauksson, Valur Bógason, Jóhann Sigurjónsson, and Gísli Víkingsson, Multispecies interactions in the C Atlantic |
| SC/5/ME/14 | Gunnar Stefánsson and Ólafur K. Pálsson, A framework for multispecies modelling of Boreal systems |
| SC/5/ME/15 | Pia Barner Neve, The diet of minke whales in West Greenland - a short review |

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|---|---|
| SC/5/13 | Report of the Workshop on Harp Seal-Fishery Interactions in the Northwest Atlantic: Toward Research & Management Actions, St. John=s, Newfoundland, Canada, 24-27 February 1997. Canadian Centre for Fisheries Innovation and Memorial University of Newfoundland: I-vi + 41pp. |

ANNEX 2

# REPORT OF THE SCIENTIFIC COMMITTEE WORKING GROUP ON SEALWORM INFECTION

Tromsø, Norway, 10-13 March 1997

## 1-3. OPENING PROCEDURES

The Chairman of the Working Group, Geneviève Desportes (Faroes), welcomed participants to the meeting (see Appendix 1). She noted that the Working Group had been established by the Scientific Committee to address the following request forwarded from the Council of NAMMCO at its last meeting in March, 1996:

AAware that the population dynamics of the sealworm (*Pseudoterranova decipiens*) may be influenced by sea temperature, bathymetry, invertebrate and fish fauna, the Scientific Committee was requested to review the current state of knowledge with respect to sealworm infection and to consider the need for comparative studies in the western, central and eastern North Atlantic coastal areas, taking into account the priority topics recommended by the Scientific Committee and its *ad hoc* Working Group on grey seals≅ (*NAMMCO Annual Report 1996*: 28 & 111-116).

The draft Agenda was revised and adopted as contained in Appendix 2. Invited experts Sophie des Clers (UK) and Wayne Stobo (Canada) acted as rapporteurs.

## 4. REVIEW OF DOCUMENTS

Documents available to the Working Group (Appendix 3) were reviewed.

## 5. SEALWORM LIFE HISTORY

Electrophoretic analyses have revealed that there exist three sibling species of *Pseudoterranova decipiens*, termed A, B and C (Paggi et al. 1991). In the northwest Atlantic, sibling B is found in grey and harbour seals, sibling C in bearded seals, and sibling A is lacking. In the northeastern Atlantic and the Norwegian Sea, siblings A and B occur in both grey and harbour seals, with A more abundant in grey seals and B more abundant in harbour seals. Sibling C is also found in bearded seals in European Arctic waters. Di Deco et al. (1994) described the morphometric differences between mature males of these sibling species, but at present no clear morphological differences can be seen in immature stages or mature females.

These sibling species might have different life histories. The status of the sibling species is not clear in many of the studies performed on the eastern side of the North Atlantic, and on the western side it is assumed that only sibling B is found on the Grand Banks, the Scotian Shelf and the Gulf of St. Lawrence.

### *5.1 Invertebrate host*

A review of available information on infections in invertebrates has shown that, although natural sealworm infections have not been found in copepods, harpacticoid and cyclopoid species are susceptible to infection in the laboratory. Natural infections have been found, however, in various macro-invertebrates (Table 1) (McClelland 1990; SC/5/SI/12). Experimental evidence from McClelland (1995) questioned the necessity for a copepod host, although participation of a copepod in the life cycle enhances transmission to the macro-invertebrate. To date, mysids appear to be the most probable macro-invertebrate intermediate host in Canadian waters (Martell and McClelland 1995; Marcogliese 1992; 1993a; 1996; Marcogliese and Burt 1993). In a worldwide context, groups other than mysids could be as important, depending on changes in local invertebrate communities with substrate etc. No new information was available on the growth or longevity of worms in invertebrate hosts. Host life spans vary between a few weeks or months for small hosts to one or two years for the largest hosts.

### *5.2 Small benthophagous fish*

It was noted that the pepsin digestion technique on fresh fish was far superior than the candling technique for detecting small worms. Worms 2 -10 mm in length, similar in size to those described from invertebrate hosts, have been found with this technique (SC/5/SI/11). It is likely that small worms in fish had been missed before. New information on naturally infected small fish species has been presented where density of infection could be very high (Table 2). Benthic feeders have the highest density of worms (McClelland 1995). It was noted that, density of infection (nos. of worms / unit host weight) was more relevant than sealworm abundance (mean nos of worms / host) in quantifying transmission at this level.

In the Northwest Atlantic, distinguishable modes were found in the length frequency distributions of worms in small fish. The modality in worm lengths also suggested a possible seasonal pulse of infections which may be linked to seasonal changes in availability of macro-invertebrate hosts such as mysids (Martell & McClelland 1995). Similar modes in the size distribution of worms were observed in Norwegian fish for three anisakid species (Andersen pers. comm.).

The high level of infection in these fish indicates the magnitude of the long-lived sealworm reservoir in the environment. The dynamics of bullrout as a reservoir host of sealworm have been described (Aspholm et al. 1995).

### *5.3 Piscivorous fish*

As investigations continue, more piscivorous fish species have been found to be infected (Andersen et al. 1995; Marcogliese 1995). Young fish are infected when they feed on benthic crustaceans. In some cases an increase in infection has been observed as fish change diet to become piscivorous (cod - McClelland et al. 1990; sculpins - SC/5/SI/4). In some systems, there was a decline in infection observed in the largest and oldest fish (SC/5/SI/10). Within the oldest age-classes Andersen found a decrease in the levels of infection of the larger fish (SC/5/SI/4). These declines could be due to death of worms, death of the most heavily infested fish, or due to emigration and immigration of fish. Finally, as abundances of larval sealworm increase, an inverse relationship between infection levels and host size or age may develop in fish species which accumulate most of their nematodes when they are young (McClelland et al 1990; Martell & McClelland 1995)

Larval sealworm may survive indefinitely in fish hosts. Hemmingsen et al. (1993 & pers. comm.) report no evidence of worm mortality in captive cod after four years, while in Canada, there was evidence neither of mortality, nor encapsulation of sealworm in plaice held in the laboratory for five to six years (SC/5/SI/10; Marcogliese pers. comm.). Evidently, the parasites continue to migrate in the flesh of plaice throughout the course of infection (McClelland pers. comm.).

### *5.4 Seals*

There is no new information to resolve the magnitude of host response in grey seals or harbour seals to different levels of worm abundance. Worm survival in seal stomachs has not been quantified, but an on-going project at Dalhousie has indicated that egg production was still significant from worms in captive grey seals six months after exposure (McClelland, pers. comm.). Individual worm fecundity (number of eggs *in utero*) increases with worm length (McClelland 1980; Marcogliese, pers comm). In a study in progress, the lengths of >20,000 mature sealworm and *Contracaecum osculatum* from Nova Scotian grey and harbour seals have been determined in an effort to analyse variations in size and fecundity of the nematodes with host species, age (size) and geographical origin, time of year, and worm densities in host stomachs (McClelland, pers. comm.). Fecundities will be estimated from nematode fecundity/length regressions based on subsamples of worms from each host species.

So far, there has been no evidence of a reduction in worm fecundity with total or specific worm infection levels (sealworm and *Contracaecum*, Marcogliese, pers.comm.). Both McClelland (1982) and Brattey (1990) reported experimental egg hatching rates greater than 90%.

### *5.5 Recommendations / Research needs*

The Working Group concluded and recommended the following:

- Pepsin digests should be used for large-scale invertebrate surveys;
- Experimental research is needed to study possible changes of behaviour for infected hosts;
- The pepsin digestion technique on fresh fish is far superior to candling procedures:
- Further analyses of the samples already collected from seal stomachs are needed to improve our knowledge of worm fecundity.
- In order to model the system, experimental work is required to estimate the worm=s total fecundity, including the duration of prepatency and of egg production period (patency);
- In the Northeast Atlantic processing of existing samples for sealworm abundances in different seal species should be completed;
- In the Northwest Atlantic, further parasite data should be collected in the Gulf of St. Lawrence from harp seals to determine the extent to which they are contributing to sealworm levels in groundfish.

## 6. ENVIRONMENTAL FACTORS INFLUENCING THE LIFE CYCLE

### *6.1 Temperature*

Recent experimental work shows that sealworm eggs do not hatch in water temperatures below 0E C (Measures 1996). This may explain a decline in sealworm infection observed in grey seals (Marcogliese et al. 1996), cod and plaice (Boily & Marcogliese 1995) following a period of cold waters in the Gulf of St Lawrence after 1988 (see Figure 1). Similarly, McClelland presented results showing reduced infection levels in plaice on the Breton and Scotian shelves and the Gulf of Maine, and attributed them to lower water temperatures (SC/5/SI/10).This event may also explain a reduction in the proportion of mature worms from Sable Island grey seals in 1989 (SC/5/SI/15). Sealworm levels subsequently rebounded in certain locations in the southern Gulf of St. Lawrence and the Scotian-Fundy fisheries (Figs. 2 & 3). It was noted that there was limited sea temperature data other than from satellite for inshore areas along the Canadian coast; in the central and Northeast Atlantic, inshore data are more readily available.

### *6.2 Bathymetry*

Sealworm infections are prevalent on the continental shelf and are not found in deep water systems beyond the shelf edge and some Norwegian fjords. Infected fish caught in deeper waters are assumed to be migrants from the shelf.

### *6.3 Other factors*

The species composition of invertebrate and small fish communities may vary substantially with substrate type, and may cause extensive local variability in infection levels (SC/5/SI/4; SC/5/SI/5; SC/5/SI/14).

Marcogliese mentioned a forthcoming theoretical study of sealworm egg dispersion by marine currents (McConnell et al. in press).

### *6.4 Recommendations / Research needs*

The Working Group agreed that further work was needed to:

- investigate the role of sea temperature on sealworm transmission and development;

- gather long term time series of sea temperature and sealworm infection in fish from cold water areas (near the 0EC threshold) on both sides of the North Atlantic in order to monitor possible effects of climate change;

- examine the relationship between distribution of sealworm infections in fish and seals with sea temperature for near shore waters around Iceland, Norway and the UK using a Geographical Information System (GIS);

- categorize habitat types (substrate, vegetation, invertebrate and fish communities) in order to compare infection rates between seal and fish populations.

## 7. BEHAVIOURAL FACTORS INFLUENCING HOST WORM LEVELS

### *7.1 Macro-invertebrates*

Evidence from other parasitic worm systems (Buckner et al. 1978) show that invertebrates found in the stomachs of predators are more heavily infected with larval helminths than those sampled from invertebrate populations at large. This would suggest that infected invertebrate hosts could be more susceptible to predation than non-infected ones. McClelland observed behavioural aberrations in infected copepods (1982) and amphipods (1990).

### *7.2 Fish*

Sealworm infections may reduce swimming speed in fish (Sprengel & Luchtenberg 1991). Sealworms have been found to secrete volatile ketones while in the musculature of the fish which could have an anaesthetic effect (McClelland 1995 & pers. comm.). Various members of the Working Group also speculated that, through their behaviour, activity patterns and habitat selection, individual fish, such as "red" inshore cod, may be exposed to infection more frequently. More information needs to be analysed on the extent of migration and movements of such fish.

### *7.3 Seals*

In harbour seals in a patchy habitat, individual differences in foraging behaviour appear to be persistent (Bjørge et al. 1995). Thus differences in individual seal foraging may explain some of the high variability of sealworm abundances in seals, and only a few heavily infected seals may be needed to maintain high infections in fish in small, relatively confined areas. This has been illustrated in an isolated brackish pond on Sable Island (Canada) where a small number of harbour seals caused extremely high levels of infection (>4000 worms/kg) in sticklebacks (Marcogliese 1996).

### *7.4 Recommendations / research needs*

The Working Group agreed that further research was needed in the following areas:

- Experimental work is needed to estimate the extent of increased susceptibility to predation of infected invertebrates and fish;

- The habitat use and foraging behaviour of individual seals needs to be studied and taken into account in assessments of the harbour seal as host for *Pseudoterranova decipiens* in a patchy environment

## 8. TEMPORAL AND SPATIAL VARIATIONS IN LEVELS OF SEALWORM INFECTION

### *8.1 Long-term trends*

In Canada, surveys of Canadian plaice (*Hippoglossoides platessoides*) conducted since 1980 have revealed complicated long term trends in larval sealworm infection levels, with a general increase throughout the 1980s (McClelland et al. 1983a;1983b; 1985, 1987, 1990) followed by a decline in some areas after 1990 (Figures 2 & 3). The decline has been attributed to a cold water event, which may have had a direct negative effect on embryonation and hatching of sealworm eggs (Boily & Marcogliese 1995; Marcogliese 1995), but which may also have influenced transmission of the parasite indirectly, through changes in distributions and abundances, and hence, availability of important intermediate hosts (SC/5/SI/10). By 1995-96, infection levels in plaice from many sites in the southern Gulf of St. Lawrence, Breton and Scotian Shelves, and southwestern Nova Scotia had begun to increase again (SC/5/SI/10; Figures 2 & 3).

In grey seals from Sable Island, data collected in 1983 and 1989 have shown no evidence of changes in sealworm levels within seal age groups (SC/5/SI/15), although the grey seal population has been increasing by over 12% annually during that period (Stobo & Zwanenburg 1990). Two surveys (1985-87 and 1988-92) have shown that sealworm abundances have declined in both adult and juvenile grey seals from eastern Nova Scotia, and have also fallen in juvenile and adult harbour seals in the Bay of Fundy (McClelland pers. comm.; SC/5/SI/16). In the northern Gulf of St. Lawrence, Marcogliese et al. (1996) found a decline in sealworm levels in grey seals for several age groups, although the population size was increasing (Zwanenburg & Bowen 1990). These declines parallelled declines in cod (Boily & Marcogliese 1995).

In Iceland, there were no changes in infection levels in cod in three surveys conducted in 1980-1985, 1988 and 1990-91(SC/5/SI/14). Similarly, Icelandic surveys of sealworm levels in grey seals of 4 years and older, conducted in 1979-82 and 1989-93, also showed no changes (Ólafsdóttir & Hauksson, submitted), although there has been a progressive reduction in the grey seal population since 1986 (SC/5/SI/14).

### *8.2 Medium-term trends*
Although Norway has no long-term time series of seal abundance or sealworm infection in cod, a five year study (1990-94) in the Oslofjord has followed the effect of the common seal epizootic of 1988. Although the epizootic killed two thirds of the harbour seals in the North Sea region, no changes were observed in sealworm infections in cod and sculpins (des Clers & Andersen 1995; Aspholm et al. 1995).

Surveys of nematode infections in various fish and seal species in Norwegian waters have been made in different localities, and are continuing (Aspholm pers. comm.). Sealworm levels in cod were documented in detail in the 1960s in the UK (des Clers 1991) and an annual survey of sealworm levels in cod from Scottish waters took place between 1990 and 1994 (SC/5/SI/9).

### *8.3 Seasonal trends*
A complex set of seasonal changes in seal behaviour, fish migration and environmental factors are likely to create seasonal variations in sealworm transmission.

It has been suggested that sealworm infections in plaice and small benthic feeding fish in offshore areas (SC/5/SI/11) could be linked to the local availability of mysids and acquired mainly in the winter or early spring. In Norway and the UK, circumstantial evidence suggests that young cod born late in the spring may only become infected in their second year, while early recruits may be infected in the first year of life, pointing to a limited window of transmission from invertebrate hosts (des Clers pers.comm.).
In a small sample of harbour seals, Pálsson (1977) observed that sealworm levels were lower in seals which consumed capelin than in those preying on demersal species. However, this was not confirmed in a more extensive sample from 1979-82 (SC/5/SI/14).

Along the west coast of Iceland, changes in the activity patterns of grey seals during breeding resulted in reduced mobility and local foraging on heavily infected fish species such as bullrout (SC/5/SI/14).

Surveys of nematode infections in various fish and seal species have been conducted in Norwegian waters (Aspholm, pers comm). Analyses of seasonal variations in infection levels are ongoing.

### *8.4 Spatial variability*
A long term time series of larval sealworm infection levels in *Hippoglossoides platessoides*, surveyed throughout Atlantic Canada (SC/5/SI/10), has revealed complex patterns in the temporal and spatial

distributions of the parasite. However, the highest infection levels were generally recorded in fish from areas of high grey seal density such as Sable Island Bank.

In Icelandic waters sealworm abundance was significantly lower in long rough dab and bullrout from north eastern Iceland compared to other areas (SC/5/SI/14).

On a more local scale, high infection levels in fish were observed close to seal haul-out sites in the Oslofjord, Norway (Andersen et al. 1995; Aspholm et al. 1995; SC/5/SI/4, SC/5/SI/5) and in Varangerfjord, northern Norway (SC/5/SI/6).

### *8.5 Recommendations / research needs*

The Working Group concluded and recommended the following:

- There is a need for a standardized sampling protocol to be developed for long term sampling programmes;.

- There is a need to establish long-term time series in the Central and Northeast Atlantic. Associated biotic and abiotic information should be collected in order to allow comparison of data between years and sites;

- Caution is needed in the interpretation of infection levels in seals when sample sizes are small. No recommendation could be devised as to the most suitable age group of seals to be sampled;

- There is a need to define the abiotic and biotic systems involved in each study area since the variability of *P. decipiens* is related to very different spatial scales.

## 9. DYNAMICS OF SEALWORM INFECTIONS

### *9.1 Influence of seal abundance*

In the long-term there appears to be a relationship between increasing worm infections in fish and seal abundance. However, various evidence presented to the Working Group indicated in the short term a lack of direct correspondence between changes in seal abundance and response in sealworm infection levels. In the Northwest Atlantic, grey seal populations have been increasing at rates of 6-12% annually while sealworm infection levels have shown increases, decline, or stability in various intermediate hosts. In Iceland, sealworm infections in fish have remained stable despite a reduction in the grey seal population. In the Northeast Atlantic, the 1988 epizootic reduced the harbour seal population by two thirds, yet the infection levels in various intermediate hosts have shown no declines, or only a temporary decline restricted to the year following the epizootic.

Evidence was presented which suggested that differences in behaviour between harbour seals and grey seals are consistent over the North Atlantic, and when both seal species are present, grey seals have heavier infections than harbour seals (McClelland 1980). The distributions of seals, and hence the magnitude and scope of their impact on worm levels in fish, however, is greatly influenced by the extent of the continental shelf. As a consequence of the narrow shelf found in some areas of the northeast Atlantic, movements of grey seals are restricted to coastal areas where their range often overlaps that of harbour seals. Although harbour seals are less abundant than grey seals in many areas, they may transmit high local infections to fish (Norway, Germany and UK) because of their limited foraging range.

Investigations reveal that when harp seals enter the coastal waters of northern Norway, their anisakid nematode communities come to resemble those of grey seals (SC/5/SI/6).

The Working Group concluded that:

i) sealworm infection levels in intermediate hosts are not necessarily correlated with seal abundance changes, at least in the short and medium terms. The impact of changes in seal abundances may be mitigated by other factors such as environmental temperature and intermediate host abundance and distribution;

ii) the presence of either grey seals or harbour seals can lead to sealworm infections in fish over the entire North Atlantic region. Reduction of either species may not therefore result in a significant reduction in sealworm infections in fish.

iii) individual worm levels in seals vary to such an extent that a few seals can still maintain high infection levels in fish;

iv) although harbour seals are less abundant than grey seals in many areas, they could be responsible for high local infections in fish because of their limited foraging range.

### *9.2 Miscellaneous: other parasite species*

In seals, the examination of other parasite species is important as it provides corroborative information on the diets and migratory activities of the hosts, and on possible impacts of large scale environmental changes. This was noted for *Contracaecum* and *Pseudoterranova decipiens* in grey seals from Anticosti Island in Canada (Marcogliese et al. 1996) and in grey seals from the eastern shore of Nova Scotia (McClelland pers.comm.).

### *9.3 Recommendations / research needs*

Given that in Iceland: i) the grey seal population has been reduced from 14,000 to 8,000 between 1986 and 1995; ii) a major survey of sealworm in Atlantic cod is underway; and iii) historical data on levels of sealworm infection in seals and cod exist, the Working Group **recommends** that an intensive survey of anisakid nematodes in grey seal stomach be undertaken in Iceland at the same time. This represents a unique opportunity to examine the relationship between sealworm levels in fish and seals, and a dramatic reduction in a grey seal population. Such a project should be initiated as soon as possible before the population grows to former levels. Other seal prey species known to be important hosts for sealworm (e.g. bullrout) should also be surveyed.

## 10. MODELLING OF SEALWORM INFECTION

The Working Group agreed that modelling was now a priority in order to bring together and analyse the considerable amount of new data collected since the last workshop (Bowen (ed.) 1990). Although some needs for further data collection were identified by the Working Group, it was agreed that enough new information was available to make a substantial advance over previous modelling efforts. It was also agreed that more than one modelling approach was desirable. Models should originally be developed for a specific system (e.g. main seal species, specific geographical location and fish and invertebrate communities). However, models should also be applied to other systems in order to test the universality of underlying assumptions.

The prime reason for modelling would be to provide insight to marine resource managers on the main factors influencing the dynamics of the host-parasite system. Predictive capability is required to assess the likelihood of effectively controlling infections in exploited fish species. In systems where control is likely, the models should provide a means to assess the results of proposed control measures.

Optimally, the models need to be kept as simple as possible, while taking into account the main features of the interactions between hosts and parasites and the dynamics at each host level. For example, the growth of fish could be described for both non-exploited and exploited key fish species. In many Central and Northeast Atlantic systems, the migration patterns of key fish species may also need to be modelled. Recent observations in the Gulf of St. Lawrence suggest that environmental changes may have had substantial threshold effects on the ability of sealworm eggs to hatch. This mechanism should be included in modelling that system. Models constructed should be able to account for situations where abundance of sealworm in groundfish is not correlated with abundance in seals.

***Recommendation***
The Working Group **recommends** that a workshop be convened to undertake the modelling exercise, involving both modellers and those familiar with the various biological systems in the North Atlantic. Any modelling exercise should include alternative approaches.

## 11. NEEDS FOR COMPARATIVE STUDIES IN THE NORTH ATLANTIC

In order to test the universality of sealworm models, there is a need for comparative studies. This can only be achieved through the development of long-term databases on sealworm infections for systems in the Northeast and Central Atlantic, and the development of comparable data sets for inshore systems from the Northwest Atlantic.

## 12. FUTURE WORK - RECOMMENDATIONS

In addition to the specific recommendations and research needs identified under the items above, the Working Group also **recommends** that:

- the question of sibling species in *P. decipiens* should be resolved, as well as the possibility of variations in the life history of these sibling species;

- Investigations of invertebrate infections using the pepsin digest methods should be increased;

- the relationship between fecundity and sealworm size should be established;

- due to the continuing concern regarding *P. decipiens* in the North Atlantic, research efforts to resolve the relationships between parasite and hosts should be enhanced.

## 13. ADOPTION OF REPORT

The report was adopted at 00:40, 13 March 1997.

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# AGENDA

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**LIST OF DOCUMENTS**

| | |
|---|---|
| SC/5/SI/4 | K. Anderson, Population structure of *Pseudoterranova decipiens* in the common sculpin (*Myxocephalus scorpius*) from two areas in Norway. |
| SC/5/SI/5 | S-G.Lunneryd, P. E. Aspholm & K.I. Ugland, Sealworm (*Pseudoterranova decipiens*) Infection Dynamics in Colonies of Harbour Seals (*Phoca vitulina*). |
| SC/5/SI/6 | K.I. Ugland & P. E. Aspholm, Communities of gastric nematodes in grey seals and harp seals off the northeastern coast of Norway. |
| SC/5/SI/7 | A. Bjørge, The Significance of Behavioral Traits in Seals Exposure to Cod Worm. |
| SC/5/SI/9 | S. des Clers, et.al. Monitoring sealworm infections in Scottish cod (*Gadus morhua*) landings. |
| SC/5/SI/10 | G. McClelland, R.K. Misra, and D.J. Martell. Spatial and temporal variations in prevalance and abundance of larval sealworm, *Pseudoterranova decipiens* (Nematoda: Anisakinæ), in Amercian plaice, *Hippoglossoides plantessoides*, in eastern Canada. |
| SC/5/SI/11 | G.McClelland, and D.J. Martell, Juvenile Canadian plaice (*Hippoglossoides platessoides*), and other small benthic consumers as primary fish hosts of larval sealworm (*Pseudoterranova decipiens*) in eastern Canada. |
| SC/5/SI/12 | D.J. Marcogliese, Distribution and abundance of sealworm (*Pseudoterranova decipiens*) in macroinvertebrate hosts in eastern Canada. |
| SC/5/SI/13 | D.J. Marcogliese, Distribution and abundance of sealworm (*Pseudoterranova decipiens*) and other anisakid nematodes in fish and seals in the Gulf of St.Lawrence: potential importance of climatic conditions. |
| SC/5/SI/14 | D. Ólafsdóttir, Sealworm (*Pseudoterranova decipiens* sensu lato) infections in Icelandic common and grey seals and their fish prey. |
| SC/5/SI/15 | W. Stobo and G.M. Fowler, Sealworm (*Pseudoterranova decipiens)* dynamics in Sable Island grey seals (*Halichoerus grypus*): seasonal fluctuations and changes in total burdens during the 1980s. |
| SC/5/SI/16 | G. Mc Clelland, Anisakine nematodes in grey (*Halichoerus grypus*) and harbour seals (*Phoca vitulina*) from the Gulf of St.Lawrence, eastern Nova Scotia and the lower Bay of Fundy. (Summary) |

**Table 1.** List of invertebrates naturally infected with sealworm (*Pseudoterranova decipiens*). Abundance values, expressed as number per 1000 are provided when available.

| Species | Location | Year | Abundance | Reference |
|---|---|---|---|---|
| Crustacea | | | | |
| <u>Amphipoda (Gammaridea)</u> | | | | |
| *Marinogammarus obtusatus*[1] | White Sea | 1984 | 7.5 | Val´ter (1987) |
| *Gammarus lawrencianus* | Northwest Arm, N.S. | - | 1.5 | McClelland(1990) |
| *Unciola irrorata*[2] | Northwest Arm, N.S. | - | 2.0 | McClelland(1990) |
| *Americochestia megalophthalma* | North beach, Sable Island | 1990<br>1991 | 4.6<br>1.3 | Marcogliese(1993a)<br>Marcogliese(1993a) |
| *Amphiporeia virginiana* | South beach, Sable Island | 1991 | 2.5 | Marcogliese(1993b |
| *Gammarus spp.*[3] | Wallace Lake, Sable Island | 1992<br>1994 | 0.5<br>0.3 | Marcogliese (1996)<br>Marcogliese(1996) |
| <u>Amphipoda (Caprellidea)</u> | | | | |
| *Caprella septentrionalis*[4] | White Sea | - | - | Val´ter (1978) |
| <u>Isoopoda</u> | | | | |
| *Idothea neglecta*[5] | Norway | - | - | Bjørge (1979) |
| <u>Decapoda</u> | | | | |
| *Sclerocrangon boreas* | Barents Sea | - | - | Uspenskaya (1963) |

[1] 1047 specimens of *m. obtusatus* were collected from Passamaguoddy Bay, N.B. in 1991. No sealworm were found (Marcogliese and Burt, 1993).

[2] 3874 specimens of *U. irrorata,* and a total of 17, 800 amphipods belonging to 35 species were collected from Sable Island Bank in 1989-90. No sealworm were found (Marcogliese pers.comm.; SC/5/SI/12).

[3] Amphipods were reported as *Gammarus oceanicus* in Marcogliese (1992) and *G. oceanicus* and *Gammarus setosus* in Marcogliese (1993a). However, there since has been some disagreement among experts who have examined specimens of *G. setosus*, one claiming it is *G.setosus* and another, *G. lawrencianus*. For that reason they were reported as *Gammarus spp*. in Marcogliese (1996).

[4] 1664 specimens of *Caprella linearis* were collected in Passamoguoddy Bay, N.B. in 1991. None were infected with sealworm (Marcogliese and Burt, 1993).

[5] These infected specimens were collected from the stomach contents of fish.

| Species | Location | Year | Abundance | Reference |
|---|---|---|---|---|
| Mysidacea | | | | |
| *Mysis* spp. | Bras d=Or Lakes, N.S. | 1960 | 0.6 | Scott and Black (1960) |
| *Mysis mixta* | Bras d=Or Lakes, N.S. | - | - | Scott and Black (1960) |
| | Sable Island, N.S. | - | - | Martell and McClelland (1995)[5] |
| *Neomysis integer* | Elbe estuary | - | - | Lick (1991) |
| *Neomysis americana* | Wallace Lake, 1990 | 1.1 | Marcogliese (1992) | |
| | Sable Island | 1991 | 0.9 | Marcogliese (1993a) |
| | | 1994 | 4.0 | Marcogliese (1996) |
| | Middle Wallace Lake, Sable Island | 1990 | 1.5 | Marcogliese (1992) |
| | Sable Island Bank | 1995 | 2.3 | Marcogliese (1996) |
| *Mysis stenolepis* and/or *Neomysis americana* | Bras d=Or Lakes, N.S. | 1993 | 0.2 | Jackson et al. (in press) |
| | St. Ann=s Bay, Cape Breton Island, N.S. | 1993 | 0.5 | Jackson et al. (in press) |
| Annelida (Polychaeta) | | | | |
| *Lepidonotus squamatus* | White Sea | 1962-64 | 1.0 | Val=ter & Popova (1974) |

**Table 2.** Levels of larval sealworm (*Pseudoterranova decipiens*) infection in small benthic consumers in Norway, Iceland and Canada.

| Host | | | *P.decipiens* levels | | | |
|---|---|---|---|---|---|---|
| Species | Length (cm) | Location | n | Prev (%) | Abd. | Dens. (no.kg$^{-1}$) |
| *Lophius americanus* (Juvenile) | ∃30 | Canada - Sable Is. | 15 | 60 | 5.07 | 21 |
| | | SW Nova Scotia | 27 | 7 | 0.07 | 1 |
| *Ciliata mustela* | ? | Norway - Hvaler | 10 | 80 | 2.50 | 26 |
| *Enchelyopus cimbrius* (mature) | ? | Norway - Hvaler | 195 | 14 | 0.16 | 1 |
| | 15-30 | Canada - E Nova Scotia | 23 | 52 | 2.82 | 29 |
| | | Sable Is. | 56 | 89 | 3.91 | 117 |
| | | SW Nova Scotia | 9 | 33 | 0.67 | 14 |
| | 4-24 | Atlanticosti Is. | 35 | 0 | 0 | 0 |
| *Gadus morhua* | 19-56 | Iceland - Breidfj. | 31 | 52 | 1.74 | 5.7 |
| | 12-14 | Lodmundarfj. | 16 | 25 | 1.38 | 2 |
| | 18-45 | Norway - Vega | 414 | 41 | 4.8 | 4 |
| | | Hvaler | 128 | 63 | 10.0 | 26 |
| | 21-30 | Canada - E Nova Scotia | 50 | 52 | 1.18 | 8 |
| | | Sable Is. | 42 | 67 | 1.81 | 11 |
| | | SW Nova Scotia | 36 | 50 | 1.36 | 9 |
| *Melanogrammus aeglefinus* (juv.) | 21-30 | Canada - Sable Is. | 81 | 36 | 0.72 | 4 |
| | | SW Nova Scotia | 38 | 3 | 0.03 | <1 |
| *Pollachius virens* (juv.) | 17-42 | Iceland - N-Faxaflói | 73 | 43 | 2-11 | 6.8 |
| | <40 | Canada - SW Nova Scotia | 70 | 3 | 0.03 | <<1 |
| *Urophycis tenuis* (juv.) | 21-30 | Canada - Sable Is. | 129 | 13 | 0.39 | 3 |
| | | SW Nova Scotia | 57 | 2 | 0.02 | <<1 |
| | #30 | Anticosti Is. | 18 | 0 | 0 | 0 |
| | | St. George=s Bay | 31 | 10 | 0.10 | <1 |
| *Apeltes quadracus* (mature) | 3 | Canada - Sable Is. (pond) | 24 | 62 | 2.50 | 4233 |
| *Gasterosteus aculeatus* (mature) | 3 | Canada - Sable Is. (pond) | 74 | 44 | 1.30 | 927 |
| *Labrus bimaculatus* | #20 | Norway - Hvaler | 5 | 40 | 1.80 | - |
| *Lycodes reticulatus* | ″30 | Canada - E Nova Scotia | 30 | 38 | 0.56 | 7 |
| *Lycodes vahlia* | #30 | Canada - E Nova Scotia | 100 | 32 | 0.49 | 3 |
| | | Sable Is. | 13 | 62 | 2.62 | 27 |
| *Macrozoarces americanus* (juv.) | #30 | Canada - SW Nova Scotia | 58 | 47 | 1.28 | 22 |
| | #50 | St. George=s Bay | 21 | 48 | 1.00 | 3 |
| *Zoarces viviparus* | ? | Norway - Hvaler | 3 | 33 | 0.33 | 30 |

| Host | | | | | *P.decipiens* levels | | |
|---|---|---|---|---|---|---|---|
| Species | Length (cm) | Location | | n | Prev (%) | Abd. | Dens. (no.kg$^{-1}$) |
| *Eumesogrammus praecisus* (mature) | 9-20 | Canada - | E Nova Scotia | 46 | 20 | 0.20 | 7 |
| | 14-39 | | SW Newfoundland | 19 | 0 | 0 | 0 |
| *Lumpenus lumpretaeformis* (mature) | 13-42 | Canada - | E Nova Scotia | 11 | 9 | 0.09 | 3 |
| *Pholis gunnellus* (mature) | ? | Norway - | Vega | 1 | 100 | 1.00 | 110 |
| *Cryptacanthodes maculatus* (juv.) | #40 | Canada - | Sable Is. | 11 | 36 | 0.64 | 12 |
| *Callionymus lyra* | 7-15 | Norway - | Vega | 3 | - | - | 39 |
| *Agonus olophractus*8-12 | Norway - Hvaler | | 2 | - | - | 80 | |
| *Artediellus atlanticus* (mature) | 4-9 | Canada - | E Nova Scotia | 59 | 5 | 0.05 | 11 |
| | | | Sable Is. | 41 | 51 | 1.76 | 375 |
| | | | SW Nova Scotia | 30 | 0 | 0 | 0 |
| | | | Bradelle Bank | 10 | 0 | 0 | 0 |
| *Hemitripteris americanus* (juv.) | #20 | Canada - | Sable Is. | 22 | 81 | 13.41 | 157 |
| | | | SW Nova Scotia | 19 | 42 | 0.95 | 11 |
| *Myoxocephalus octodecem*spinosus | #20 | Canada - | Sable Is. | 44 | 84 | 5.57 | 187 |
| | | | SW Nova Scotia | 20 | 10 | 0.20 | 5 |
| | #30 | | SW Newfoundland | 17 | 6 | 0.12 | <1 |
| | | | St. George=s Bay | 55 | 31 | 3.36 | 19 |
| *Myoxocephalus scorpius* | 8-31 | Norway - | Vega | 248 | 76 | 23.2 | 176 |
| | 10-36 | | Hvaler | 172 | 19 | 26.1 | 209 |
| | 17-31 | Iceland - | Breidafj. | 60 | 92 | 30.50 | 150 |
| | 17-30 | | N-Faxaflói | 71 | 100 | 95.20 | 340 |
| | 15-30 | | Lodmundarfj. | 21 | 76 | 3.70 | 10 |
| | #30 | Canada - | Anticosti Is. | 121 | 23 | 1.33 | 5 |
| | | | St. George=s Bay | 13 | 43 | 1.43 | 3 |
| *Taurulis bubalis* | 8-10 | Norway - | Vega | 2 | 50 | 1.50 | 50 |
| | | | Hvaler | 8 | 62 | - | 46 |
| *Triglops murrayi* (juv./mature) 4-16 | Canada - | E Nova Scotia | | 63 | 33 | 0.52 | 41 |
| | | | Sable Is. | 152 | 68 | 3.31 | 405 |
| | | | SW Nova Scotia | 156 | 8 | 0.12 | 17 |
| | | | SW Newfoundland | 19 | 0 | 0 | 0 |
| | | | Anticosti Is. | 36 | 0 | 0 | 0 |
| | | | Bradelle Bank | 77 | 0 | 0 | 0 |

| Host | | | | | *P.decipiens* levels | | |
|---|---|---|---|---|---|---|---|
| Species | Length (cm) | Location | | n | Prev (%) | Abd. | Dens. (no.kg$^{-1}$) |
| *Aspidophoroides monopterygius* (mature) | 8-18 | Canada - | E Nova Scotia | 17 | 6 | 0.06 | 14 |
| | | | Sable Is. | 51 | 49 | 1.04 | 285 |
| | | | SW Nova Scotia | 38 | 0 | 0 | 0 |
| *Eumicrotremus spinosus* (mature) | 3-9 | Canada - | Sable Is. | 72 | 46 | 0.82 | 65 |
| | 3-12 | | Anticosti Is. | 33 | 0 | 0 | 0 |
| *Scophthalmus aquosus* (juv.) | #20 | Canada - | Sable Is. | 55 | 85 | 3.22 | 62 |
| *Glyptocephalus cynoglossus* (juv.) | 25-49 | Iceland - | Selvogsgrunn | 56 | 18 | 0.21 | <1 |
| | 21-30 | Canada - | E Nova Scotia | 22 | 18 | 0.27 | 3 |
| | | | Sable Is. | 60 | 15 | 0.32 | 4 |
| | | | SW Nova Scotia | 17 | 24 | 0.41 | 4 |
| | ∃30 | | SW Newfoundland | 10 | 0 | 0 | 0 |
| | | | Gulf North Shore | 32 | 0 | 0 | 0 |
| | | | Gospé | 78 | 0 | 0 | 0 |
| | | | Bradelle Bank | 20 | 5 | 0-10 | <<1 |
| *Hippoglossoides platessoides* (juv.) | ? | Norway - | Vega | 10 | 50 | 1.40 | 14 |
| | 20-29 | Iceland - | Látrabjarg | 40 | 35 | 0.75 | 6 |
| | 10-19 | | Selvogsgrunn | 5 | 40 | 2.00 | 39 |
| | 20-29 | | Selvogsgrunn | 51 | 82 | 4.61 | 39 |
| | 20-29 | | Hornafj. | 42 | 88 | 2.52 | 14 |
| | 10-19 | | Langanes | 4 | 50 | 1.00 | 19 |
| | 20-29 | | Langanes | 57 | 60 | 1.28 | 10 |
| | 10-19 | | Húnaflói | 46 | 50 | 0.89 | 29 |
| | 20-29 | | Húnaflói | 75 | 70 | 1.96 | 16 |
| | 11-20 | Canada - | E Nova Scotia | 83 | 33 | 0.46 | 14 |
| | | | Sable Is. | 165 | 72 | 5.44 | 186 |
| | | | SW Nova Scotia | 67 | 55 | 1.60 | 42 |
| *Limanda limanda* | ? | Norway - | Hvaler | 33 | 10 | 0.10 | <<1 |
| | 13-29 | Iceland - | Breidafj. | 16 | 0 | 0 | 0 |
| *Pleuronectus ferrugineus* | #20 | Canada - | E Nova Scotia | 20 | 0 | 0 | 0 |
| | | | Sable Is. | 121 | 22 | 0.32 | 10 |
| | | | SW Newfoundland | 22 | 0 | 0 | 0 |
| *Pleuronectes platessa* | ? | Norway - | Hvaler | 71 | 1 | 0.01 | <<1 |
| | 14-34 | Iceland - | Breidafj. | 7 | 0 | 0 | 0 |
| | | | N-Flaxaflói | 18 | 11 | 0.11 | <1 |
| *Reinhardtius hippoglossoides* | 14-30 | Canada - | E Nova Scotia | 11 | 0 | 0 | 0 |
| | | | Sable Is. | 18 | 11 | 0.22 | 2 |
| | #30 | | Anticosti Is. | 99 | 0 | 0 | 0 |

ANNEX 3

## REPORT OF THE SCIENTIFIC COMMITTEE WORKING GROUP ON ABUNDANCE ESTIMATES

Reykjavík, Iceland, 21-23 February 1997

The Working Group met at the Marine Research Institute, Reykjavík during 21-23 February 1997, under the chairmanship of Nils Øien (Norway). The meeting was attended by members of the Working Group: Þorvaldur Gunnlaugsson (Iceland), Pia Barner Neve (Greenland), Nils Øien (Norway), Jóhann Sigurjónsson (Iceland), Gísli Víkingsson (Iceland), as well as invited participants David Borchers and Louise Burt from the Mathematical Institute, University of St Andrews, UK.

## 1. TERMS OF REFERENCE

The Working Group was established by the Scientific Committee at its fourth meeting in Tórshavn, Faroe Islands in February 1996 and was given the task:

(i) Ato review the analyses and where relevant also to analyse data from NASS-95 to ensure its compatibility, both between NASS-95 survey areas, as well as with data from other sightings surveys, in order to provide a basis for calculating abundance estimates for the relevant cetacean stocks in the North Atlantic≅, and

(ii) Ato monitor stock levels and trends in stocks of all marine mammals in the North Atlantic≅.

The Working Group coordinated its work by correspondence (led by J. Sigurjónsson, Iceland until replaced by N. Øien). The meeting in Reykjavik was the first and only meeting of the Working Group, and focused on describing synoptic distributions of the cetacean species encountered during NASS-95, and abundance estimates for minke, fin, sei and pilot whales.

## 2. PLANNING THE NASS-95 SURVEY

In 1987 and 1989 synchronized large scale cetacean sightings surveys were conducted on board vessels and aircraft allocated by the Faroe Islands, Greenland, Iceland, Norway and Spain known as the NASS-87 and NASS-89 (North Atlantic Sightings Survey) surveys, respectively (see e.g. *Rep.int.Whal.Commn* 39 (1989):395-455*; Rep.int.Whal.Commn* 41 (1991):134-138). In addition to scientists from the sponsoring laboratories, scientists from Japan, New Zealand, UK and USA were also involved in the planning and conduct of the surveys. As a result of these joint research efforts, the first synoptic view of distribution and abundance of cetaceans was obtained that covered deep and shallow areas of the northern North Atlantic Ocean from the coast of Spain in the south to the Barents Sea in the north, and as far west as to the coasts of Iceland and West Greenland south to 50EN. The surveys were planned and the results were analysed in cooperation with members of the International Whaling Commission (IWC) Scientific Committee.

In 1993 the North Atlantic Marine Mammal Commission (NAMMCO) Council decided that a North Atlantic sightings survey should be conducted under the auspices of the NAMMCO Scientific Committee. The Council requested the Scientific Committee to plan joint cetacean sightings surveys in the North Atlantic by coordinating national research programmes with the aim to obtain new abundance estimates of the principle whale species in the northern North Atlantic. The Committee decided that the survey was to take place during July-August 1995 and established a Working Group to plan the NASS-95 under the chairmanship of F. Larsen (Greenland).

The Working Group had three meetings in 1994 and 1995 (NASS-95 Working Group Report 1994a; 1994b; *NAMMCO Annual Report* 1995:121-124) to plan and coordinate activities in the NAMMCO member countries and to establish cooperation with scientists and laboratories in other relevant countries and organisations, particularly the IWC Scientific Committee and the International Council for the Exploration of the Sea (ICES). A joint meeting with experts from both organisations was held in December 1994, where theoretical and practical aspects of the survey were discussed in detail. The Norwegian part of the NASS-95 survey, NILS-95 (Norwegian Independent Line-Transect Survey), was subject to special consultations within the IWC Scientific Committee (*Rep.int.Whal.Commn* 46 (1996):61-62).

At the outset it was decided that the design and planning of NASS-95 was to be compatible with the earlier surveys in order to allow for comparison of abundance and distribution in time. During the planning phase, an increase in the area coverage to the western North Atlantic compared to earlier surveys (see Figures 1 and 2) was considered an important goal. However, efforts failed to obtain simultaneous participation by the relevant countries in the western North Atlantic. In contrast to the surveys in 1987 and 1989, no surveys were conducted off West Greenland in 1995. However, an aerial survey was conducted in that area in 1993, and reported by Larsen (1995). Observations from that survey have been used for distributional maps to indicate the extent of known distributions.

### *2.1 Target Species of the Survey*

As in earlier surveys, the participating countries had different species priorities. Norway still had minke whale (*Balaenoptera acutorostrata*) as the main target species. The Faroe Islands had greatest interest in long-finned pilot whales (*Globicephala melas*), but secondary interest in bottlenose dolphins (*Tursiops truncatus*) and northern bottlenose whale (*Hyperoodon ampullatus*). Iceland attached greatest emphasis to minke, fin (*B. physalus*) and sei whales (*B. borealis*), the last mentioned species having however less importance than the first two. It was recognized that while abundance estimation might be possible for other cetacean species observed during these surveys, the design and conduct of the survey might to a varying degree facilitate such estimation, depending on both the species and areas in question.

### *2.2 Area Coverage and Timing*

Figure 2 shows the areas covered by the NASS-95 surveys by participating countries as well as the survey blocks, where the nations had synchronised their efforts according to available resources and the over all goal. One Faroese vessel participated during the period 3 July-6 August, covering a similar area as the single vessel conducting the survey in 1989 with an additional extension to the southwest. Eleven Norwegian vessels participated during the period 5 July-8 August, covering the same areas as in 1989 as well as an extension westwards to the drift ice off East Greenland, including the Jan Mayen area. The Icelandic survey, carried out with two vessels during the period 22 June-4 August, had the main sightings effort and area coverage somewhat similar to the 1987 Icelandic survey, but earlier and more to the north than the Icelandic survey in 1989.

The Icelandic aerial survey component (7-25 July, see SC/4/17), aimed at minke whales in the coastal (depth less than 600-1,000 m) waters of Iceland, was similar both in coverage and timing as the 1987 survey (Donovan and Gunnlaugsson 1989). The track lines and survey blocks are shown in Figure 4.

## 3. METHODOLOGY

### *3.1 Shipboard Surveys*

The basic methodology used was the line-transect survey method (Buckland et al. 1993a). The Icelandic shipboard survey was conducted in a delayed-closure mode with one barrel and the upper bridge as the search platforms (Sigurjónsson et al. 1996b).

The Faroese surveys were carried out in passing mode with a random sample collected in delayed-closure mode to estimate school sizes of pilot whales (for further details, see Desportes et al. 1996). Two independent observation platforms were used, a primary platform (searched with naked eye within 1,000 m from vessel) and a tracker platform (searched with binoculars ahead and beyond 1,000 m from vessel), that operated according to a specific protocol (Buckland and Turnock 1992).

The details of the Norwegian survey design and sighting protocols are given in Øien (1995, 1996). The survey was operated in passing mode with basically two independent observer teams on watch during acceptable conditions, although minor parts of the survey were run in a one-platform configuration. Vessel speed on effort was intentionally 10 knots.

### *3.2 Aerial Survey*

The tracks were originally (1987) set out according to a procedure by Cooke and Hiby (1987), where an objective function is used to specify the drawing of the tracks such that the probability of any given point being covered can be calculated as a function of its position. The estimated population size is then calculated as the sum of reciprocals of the coverage probabilities for all the sightings. The survey was conducted (Sigurjónsson et al. 1996a) from a twin-engine high wind *Partenavia Observer P-68*, with a plexiglass bubble window on each side. The plane operated generally at an altitude of 750 feet when conditions permitted and at a speed of around 90 knots (167 km/hr).

### *3.3 Analyses*

#### 3.3.1 Shipboard Surveys

The Icelandic and Faroese data as well as the Norwegian fin whale data have basically been analysed using the Distance software package (Laake et al. 1994). The analysis of the Norwegian minke whale data are described in Schweder et al. (1996).

#### 3.3.2 Aerial Surveys

Only minke whale abundance estimation was attempted based on the data obtained by the aerial survey around Iceland. The analysis carried out (SC/5/AE/2) is based on the cue-counting method (Hiby and Hammond 1989) as described in Buckland et al. (1993a), using the computer programme DISTANCE (see Buckland et al. 1993a).

## 4. SURVEY RESULTS

### *4.1 Distribution of effort*

The on-effort track lines for all survey areas are shown in Figure 3 and compiled by survey blocks and country in Table 1.

The on-effort track line of the two Icelandic vessels was 6,125 n miles compared to a planned track line of 8,400 n miles. Of these 3,336 n miles were sailed in 0-3 Beaufort and the remaining 2,849 n miles in Beaufort 4-7. The total Icelandic survey area was 443,813 sq. n miles.

The Faroese on-effort vessel track line amounted to 1,662 n miles of which 1,153 and 509 n miles were under wind speed Beaufort 0-3 and 4-5, respectively. The total Faroese survey area was 341,183 sq. n miles.

The total Norwegian vessel survey area was 824,336 sq. n miles. The eleven participating vessels traveled on primary effort 13,522 n miles, i.e. under Aacceptable≅ weather conditions for conducting minke whale sightings (Beaufort 4 or less; visibility greater than 1 n mile).

In total the Icelandic aerial survey comprised 5,500 n miles on-track effort.

**Table 1.** *NASS-95 shipboard surveys: Distribution of effort by nations and survey area (see also Figs 3 and 4). Data are also given for Greenland 1993 aerial survey and Iceland aerial survey in 1995.*

| Nationality | Block size (sq. n miles) | On-effort (n miles) |
|---|---|---|
| Faroe Islands | 341,183 | 1,662 |
| Iceland | 443,813 | 6,125 |
| Norway | 824,336 | 13,522 |
| Iceland-aerial 1995 | 76,080 | 5,500 (approx.) |
| Greenland-aerial 1993 | 110,140 | 3,600 (approx.) |

### *4.2 Minke Whale Sightings*

### 4.2.1 Distribution

The distribution of minke whales based on NASS-95 is shown in Figure 5. Although a considerable survey effort was allocated to southern areas southwards to 52EN, the southern limit of the minke whale distribution approximately follows the 1,000 m depth contours from Greenland to the British Isles. The distribution within the area is primarily over continental shelves, but nevertheless the abundance over the deep waters of the Norwegian Sea is considerable. The NASS surveys therefore seem to give a complete picture of the summer distribution of minke whales in the northeast Atlantic.

Compared to earlier surveys, a shift in distribution was observed in the Barents Sea, as few minke whales were seen in the southeastern part off the Kola peninsula in 1995, while this was an area of high density in 1989. Around Iceland the highest densities of minke whales were found over the shelf areas and were thus covered by the aerial surveys. In the 1993 Greenland aerial survey most of the minke whale sightings were made in central and southern coastal areas, which confirms the general patterns from surveys made in earlier years.

### 4.2.2 Abundance

Abundances of minke whales are summarised in Table 2.

The coastal areas around Iceland were surveyed by aircraft and are tabulated as AX (AIR)≅. The Icelandic shipboard blocks 5 and 6 were restratified correspondingly for this analysis to avoid overlap in estimates. Thus the numbers tabulated for blocks A5 and 6≅ exclude the aerial survey block, and a shipboard estimate was calculated for the remaining parts of these blocks and tabulated as AX (SHIP)≅. AX (AIR)≅ includes coastal areas not part of AX (SHIP)≅. Since the Icelandic shipboard survey was conducted with one platform only on each of the two ships, no information is available to evaluate the bias introduced in the analyses by assuming g(0)= 1. The Icelandic shipboard survey estimates were calculated at the meeting. The overall estimate for the Icelandic ship survey blocks were 17,871 (CV = 0.225; 95% CI 11,555-27,639).

The minke whale estimates based on the Norwegian shipboard survey (Schweder et al. 1996) have been the subject of a major review by the IWC Scientific Committee (*Rep.int.Whal.Commn 48*, in press). The Working Group did not feel that they could add much to those discussions, and the estimates agreed by the IWC/SC were tabulated at face values. The over all estimate for the Norwegian survey blocks was 118,299 (CV= 0.103; 95% CI 93,746-138,720).
There were only two minke whale sightings contained in the Faroese survey data set, and thus no estimate was calculated for those blocks.

### *4.3 Fin Whale Sightings*

### 4.3.1 Distribution

The distribution of fin whale sightings made during NASS-95 are shown in Figure 6. As in previous surveys, highest densities are found in the area between Iceland and East Greenland and significant numbers were also found on the Jan Mayen Ridge and near Spitsbergen. Within the Icelandic survey area, the distribution pattern is similar to those from previous surveys, although the relative 1995 density is even higher in block 9 (Denmark Strait - Irminger Basin) than in the 1987 and 1989 surveys.

### 4.3.2 Abundance

Abundance estimates for fin whales are given in papers SC/5/AE/4 (Norwegian survey area) and SC/5/AE/1 (Icelandic and Faroese areas), and summarised in Table 3. The total estimate for the Norwegian survey area is 3,080 fin whales (CV= 0.248) based on a standard line transect analysis approach. The total abundance estimate for the Icelandic/Faroese survey area is 19,708 fin whales (CV =0.166). Adding the estimated abundance from Norwegian blocks JMC (76, CV= 0.445) and NVN (332, CV= 0.652) and subtracting 2/3 of the abundance from the Faroese blocks (as the Faroese block A is not a part of the East Greenland-Iceland (EGI) area), gives a total estimate of 18,932 (CV= 0.160) fin whales within the part of the EGI schedule stock area surveyed in 1995. This is the largest estimate for the EGI stock of fin whales to date. In particular, the abundance is considerably higher in the area between East Greenland and Iceland than in the 1987 and 1989 surveys, respectively. In fact the abundance in block 9 alone in 1995 is higher than the total abundance in all blocks from either of the previous surveys.

## *4.4 Sei Whale Sightings*

### 4.4.1 Distribution

The distribution of sei whale sightings made during NASS-95 is shown in Figure 7. Only two sightings (one primary sighting) were made by the Norwegian survey vessels, three sightings were made onboard the Faroese vessel and 103 sightings onboard the two Icelandic vessels. The distribution corresponds well with that of the 1987 and 1989 surveys, with consistent low abundance in both Norwegian and Faroese survey areas. However, the 1989 Icelandic survey was conducted somewhat later in the season when the species typically migrates into the area west off Iceland and covered areas further south with significant densities of sei whales.

### 4.4.2. Abundance

Paper SC/5/AE/1 gives the abundance estimates for sei whales by survey blocks, resulting in a total estimate of 9,249 animals (95% CI: 3,700 - 23,116), see Table 4. Of these, 722 animals (CV=0.80) were estimated in the Faroese survey area, while the rest is derived from the Icelandic survey area. Although the majority (about 70%) of the 1989 estimate (10,600, CV=0.27) were derived from survey blocks south of the 1995 survey, the two surveys are not inconsistent in light of wide confidence limits and difference in timing.

## *4.5 Pilot Whale Sightings*

### 4.5.1 Distribution

The NASS-95 distribution of pilot whales is shown in Figure 8. This distribution is complementary to the minke whale distribution; i.e. the sightings were made south of the ridge Greenland-Iceland-Faroe Islands, with a few stragglers off the Norwegian coast. This indicates that the NASS surveys cover the northernmost areas of pilot whale distribution in the northeast Atlantic.

### 4.5.2 Abundance

The abundance of pilot whales by block is given in Table 5.

The estimate (SC/5/AE/3) is based on application of a conventional line transect method. Data from all blocks were pooled for estimating the effective search width, while encounter rate and school size were estimated by block. The total abundance over all blocks is 215,000 animals (CV= 0.26).

In the areas covered by Norwegian vessels, only two primary sightings of pilot whale groups were made, of which one comprised a group of an estimated 150 individuals.

### *4.6 Other species*

Several other species were considered from a distributional point of view. The NASS-95 distribution of humpback (*Megaptera novaeangliae*), blue (*B. musculus*), sperm (*Physeter macrocephalus*), northern bottlenose (*Hyperoodon ampullatus*), killer (*Orcinus orca*), harbour porpoises (*Phocoena phocoena*) and small *Delphinidae* (*Lagenorhynchus* sp. and similar species) are shown in Figures 9-15.

## 5. TRENDS IN DISTRIBUTION AND ABUNDANCE

### *5.1 Minke whale*

Although the point estimates for the aerial surveys for coastal Iceland differ by a factor of nearly 3, that is roughly 20,000 whales from NASS-87 vs. roughly 56,000 whales from NASS-95, a large part of the difference is due to the fact that the NASS-87 aerial survey covered a substantially smaller area. There is a continuity in distribution of minke whales from Icelandic coastal areas towards the ice edge at Greenland and Jan Mayen, which may give cause for substantial movement in and out of the aerial survey area, and taking the high variances associated with the point estimates into consideration, no conclusion about trends can be made.

For the Norwegian survey blocks, large differences occured between the 1989 and 1995 estimates, most notably the block off the Kola coast in the southeastern Barents Sea, which, from being the largest contributor to the total abundance estimate in 1989, was the least important in 1995. However, aggregated on a small management area level, the abundance estimates are consistent between the two years, the 1995 estimates being roughly twice the 1989 estimates; 118,000 as compared to 68,000 animals. Although the number of minke whales within the area may have increased from increased immigration or natural rate of increase, most of the difference is probably related to the fact that the 1995 estimate was derived from a designed survey with independent teams of observers and there was no need to extrapolate from ancillary survey data as was necessary for the 1989 estimate.

### *5.2 Fin whale*

The 1995 point estimate of 19,642 (CV=0.20) in the Icelandic and Faroese survey areas appears to be higher than the estimates derived from earlier surveys. The increase in abundance is particularly noticable in the southwestern part of the survey area, between East Greenland and Iceland (Block 9). Sightings made in high Beauforts contribute significantly to the large abundance estimate in Block 9 in 1995, but the implications of this are unclear.

The abundance estimate of fin whales from the Norwegian survey area (3,080, CV= 0.25) is not significantly different from the earlier NASS surveys. In 1991 the Scientific Committee of the IWC tabulated an estimate of 15,614 fin whales in the EGI stock area, based on combined data from the 1987 and 1989 surveys (*Rep.int.Whal.Commn* 42 (1992): 600). The estimate from the NASS-95 of 18,932 fin whales is considerably higher even though the 1995 survey did not cover a large area where a significant number of fin whale sightings were made in 1989. This may reflect a true increase in the stock, while discontinuity in distribution towards the south of the survey area may indicate that the 1995 survey captured the peak of the fin whale migration to these waters better than earlier surveys.

### *5.3 Sei whale*

The estimates from the Icelandic/Faroese parts of the NASS-89 and NASS-95 surveys of 10,600 and 9,249 sei whales, respectively, appear to be in good agreement. However, the 1995 survey did not cover the south-westernmost parts of the 1989 survey area from which around 70% of the 1989 abundance estimate was derived. Although comparisons of abundance in identical subareas in the three sightings surveys may indicate an increase and/or northward shift in abundance, interpretations should be made with caution due to the relatively wide confidence limits and difference in timing of surveys. It is unlikely that any of the surveys covered the total distribution of the stock, and the species is known for relatively large between-year variations in abundance in Icelandic waters.

### *5.4 Pilot whales*

Previous surveys of long-finned pilot whales were conducted in 1987 and 1989 (Buckland et al. 1993). The area surveyed in 1995 covered a similar area to that surveyed in 1987 and extended as far south, in the eastern part of the survey area, as the 1989 survey. The total abundance estimate in 1987 was 123,000 (CV= 0.29). Excluding blocks in the 1989 survey so that the estimate was comparable to the total estimate from the 1987 data, the 1989 estimate was 191,000 animals (CV= 0.33). If the Faroese block B is excluded from the analysis, so that the 1995 estimate is broadly comparable to the 1987 and 1989 estimates, the total abundance estimate in 1995 is 181,440 (CV=0.26). The 1995 estimate is therefore consistent and not significantly different from previous estimates for the area covered.

## 6. ACKNOWLEDGMENTS

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**Table 2.** Abundance of minke whales by survey block, management area and for the total survey area. Block 9 contributes to both management areas CG and CIP.

| NATION | BLOCK | ABUNDANCE | CV | MANAGEMENT AREA | ABUNDANCE | CV | TOTAL ABUNDANCE | CV |
|---|---|---|---|---|---|---|---|---|
| **ICELAND** | 4 | na | | CIP | (contribution from block 9) | | | |
| | 7 | na | | | | | | |
| | 8 | na | | | | | | |
| | 3 | na | | | | | | |
| | 9 | 4,757 | 0.293 | 9 $\subseteq$ both CG & CIP | 4,757 | 0.293 | | |
| | 2 | na | | | | | | |
| | X (SHIP) | 7,837 | 0.333 | CIC | 55,922 | 0.310 | | |
| | X (AIR) | 55,922 | 0.310 | | | | | |
| | 5 and 6 outside X | 5,277 | 0.313 | CM | 11,451 | 0.241 | | |
| **NORWAY** | JMC | 1,339 | 0.560 | | | | | |
| | NVN | 4,835 | 0.429 | | | | | |
| | SVI | 2,691 | 0.285 | ES | 25,969 | 0.112 | | |
| | SV | 4,719 | 0.163 | | | | **184,255** | 0.116 |
| | NON | 3,357 | 0.260 | | | | | |
| | VSI | 345 | 0.406 | | | | | |
| | VSN | 1,672 | 0.195 | | | | | |
| | VSS | 1,959 | 0.233 | | | | | |
| | BJ | 7,164 | 0.234 | | | | | |
| | BAW | 4,062 | 0.265 | | | | | |
| | BAE | 16,101 | 0.299 | EB | 56,330 | 0.136 | | |
| | GA | 10,615 | 0.216 | | | | | |
| | KO | 962 | 0.567 | | | | | |
| | FI | 5,974 | 0.296 | | | | | |
| | NOS | 22,678 | 0.156 | | | | | |
| | LOC | 2,462 | 0.228 | EC | 2,462 | 0.228 | | |
| | NSC | 7,070 | 0.236 | EN | 27,364 | 0.206 | | |
| | NS | 20,294 | 0.258 | | | | | |
| **FAROE ISLANDS** | A & B | 2 primary sightings | | A $\subseteq$ EN<br>B $\subseteq$ CIP | | | | |

**Table 3.** Abundance of fin whales by survey block, management area and for the total survey area. The East Greenland-Iceland stock area comprises the areas surveyed by Iceland, the Norwegian JMC and NVN blocks, as well as one third of the Faroese A and B blocks.

| NATION | BLOCK | ABUNDANCE | CV | MANAGEMENT AREA | ABUNDANCE | CV | TOTAL ABUNDANCE | CV |
|---|---|---|---|---|---|---|---|---|
| **ICELAND** | 4 | 204 | 0.771 | | | | | |
| | 7 | 301 | 0.550 | EAST GREENLAND - ICELAND STOCK | | | | |
| | 3 | 1,146 | 0.199 | | | | | |
| | 9 | 13,745 | 0.221 | | | | | |
| | 8 | 831 | 0.320 | | 18,932 | 0.160 | | |
| | 2 | 117 | 0.619 | | | | | |
| | 6 | 143 | 0.461 | | | | | |
| | 5 | 1,445 | 0.545 | | | | | |
| **NORWAY** | JMC | 76 | 0.445 | | | | | |
| | NVN | 332 | 0.652 | | | | | |
| | SVI | 151 | 0.648 | | | | | |
| | SV | 553 | 0.334 | NORTH NORWAY STOCK | | | **22,789** | 0.147 |
| | NON | 68 | 1.702 | | | | | |
| | VSI | 15 | 1.206 | | | | | |
| | VSN | 203 | 0.456 | | | | | |
| | VSS | 88 | 0.723 | | 2,673 | 0.254 | | |
| | BJ | 563 | 0.340 | | | | | |
| | BAW | na | | | | | | |
| | BAE | 131 | 1.967 | | | | | |
| | GA | 277 | 1.072 | | | | | |
| | KO | na | | | | | | |
| | FI | 425 | 1.037 | | | | | |
| | NOS | 142 | 0.440 | | | | | |
| | LOC | 57 | 0.712 | | | | | |
| | NSC | na | | WEST NORWAY & BRITISH ISLES STOCKS | 1,184 | 0.308 | | |
| | NS | na | | | | | | |
| **FAROE ISLANDS** | A & B | 1,776 | 0.308 | | | | | |

**Table 4.** Abundance of sei whales by survey block, management area and for the total survey area. One third of the Faroese A and B blocks is added to the Iceland-Denmark Strait management area.

| NATION | BLOCK | ABUNDANCE | CV | MANAGEMENT AREA | ABUNDANCE | CV | TOTAL ABUNDANCE | CV |
|---|---|---|---|---|---|---|---|---|
| **ICELAND** | 4 | 2,914 | 0.85 | | | | | |
| | 7 | 2,173 | 0.681 | ICELAND- | | | | |
| | 3 | 0 | | DENMARK STRAIT | 8,768 | | | |
| | 9 | 3,262 | 0.856 | | | | | |
| | 8 | 146 | 1.246 | | | | **9,249** | 0.494 |
| | 2 | 32 | 0.836 | | | | | |
| | 6 | 0 | | | | | (3,700-23,116) | |
| | 5 | 0 | | | | | | |
| **NORWAY** | NOS | 1 primary sighting | | EASTERN | 481 | 0.80 | | |
| **FAROE ISLANDS** | A & B | 722 | 0.80 | STOCK | | | | |

**Table 5.** Abundance of pilot whales by survey block and for the total survey area.

| NATION | BLOCK | ABUNDANCE | CV | TOTAL ABUNDANCE | CV |
|---|---|---|---|---|---|
| **ICELAND** | 4 | 7,585 | 0.803 | **214,840** | 0.260 |
| | 7 | 19,490 | 0.443 | | |
| | 3 | na | | | |
| | 9 | 45,057 | 0.460 | | |
| | 8 | 42,940 | 0.855 | | |
| | 2 | na | | | |
| | 6 | na | | | |
| | 5 | na | | | |
| **NORWAY** | LOC | 2 primary sightings, one group 150 animals | | | |
| **FAROE ISLANDS** | A & B | 99,768 | 0.630 | | |

**FIGURE LEGENDS**

*Fig 1. Area coverage for NASS-87, NASS-89 and NASS-95.*

*Fig 2. Stratification of survey blocks for NASS-95.*

*Fig 3. Realised effort for shipboard part of NASS-95.*

*Fig 4. Aerial survey transects off West Greenland in 1993, and survey blocks and transect for the Icelandic aerial survey part of NASS-95.*

*Fig 5. Distribution of minke whale sightings during NASS-95. For West Greenland observations made during the 1993 aerial survey are plotted.*

*Fig 6. Distribution of fin whale sightings during NASS-95. For West Greenland observations made during the 1993 aerial survey are plotted.*

*Fig 7. Distribution of sei whale sightings during NASS-95. For West Greenland observations made during the 1993 aerial survey are plotted.*

*Fig 8. Distribution of pilot whale sightings during NASS-95. For West Greenland observations made during the 1993 aerial survey are plotted.*

*Fig 9. Distribution of humpback whale sightings during NASS-95. For West Greenland observations made during the 1993 aerial survey are plotted.*

*Fig 10.Distribution of blue whale sightings during NASS-95.*

*Fig 11 Distribution of sperm whale sightings during NASS-95. For West Greenland observations made during the 1993 aerial survey are plotted.*

*Fig 12 Distribution of Northern bottlenose whale sightings during NASS-95.*

*Fig 13 Distribution of killer whale sightings during NASS-95. For West Greenland observations made during the 1993 aerial survey are plotted.*

*Fig 14.Distribution of harbour porpoises sightings during NASS-95.*

*Fig 15.Distribution of small Delphinidae sightings during NASS-95.*

Tromsø, 17 March 1997

# - PRESS RELEASE -

**The Scientific Committee of NAMMCO - the North Atlantic Marine Mammal Commission - met in Tromsø, Norway, 10-14 March 1997. The meeting was attended by scientific experts appointed to the Committee from NAMMCO member countries (Norway, Iceland, Greenland and the Faroe Islands). As well, a number of invited experts from across the North Atlantic, including Canada, Iceland, Norway, the UK and Russia, contributed to the Committee=s special focus this year on questions related to the role of whales and seals in the marine ecosystem. Some of the major conclusions and recommendations of the Scientific Committee can be summarised as follows:**

****	Estimates of whale abundance in the North Atlantic***

New information on the abundance of several whale stocks in the North Atlantic was reviewed. Data from the 1995 North Atlantic Sightings Survey for cetaceans (NASS-95), which was coordinated through NAMMCO, was used as the basis for revised estimates for the surveyed areas.

- The current best estimate of the central North Atlantic stock of **minke whales** is 72,000. Combined with the estimate of 112,000 from the Norwegian part of the survey in the Northeast Atlantic, which was reviewed by the Scientific Committee of the International Whaling Commission in 1996, this gives a total estimate of 184,000 minke whales in the central and northeast Atlantic.
- The Scientific Committee concluded that the abundance of **fin** and **sei whales** in North Atlantic waters east of Greenland was 22,800 and 9,250 respectively.

*	***Long-finned pilot whales***

Pilot whales are of particular interest for the Faroe Islands. Data from the NASS-95 survey did not result in significantly different estimates of abundance, and the earlier number of 778,000 pilot whales in the northeast Atlantic was still considered to be the best estimate. The Scientific Committee concluded that the effects of historic and present catches in the Faroe Islands have had a negligible effect on the long-term trends in the stock.

****	Role of marine mammals in the ecosystem***

- <u>Fish consumption of minke whales, harp seals and hooded seals in the North Atlantic</u>

Based on a review of recent results from ecological studies, the Scientific Committee concluded that minke whales, harp seals and hooded seals may have substantial direct and/or indirect effects on commercial fish stocks. As an example it was shown that stocks of minke whales and harps seals in the Barents Sea and off northern Norway may consume 2.5-3.5 million tons of prey per year, more than half of which is commercially important fish.

- To better understand the possible effects of this consumption, the Scientific Committee recommended that knowledge be improved in a number of areas, such as variations in abundance, distribution, diet, energy requirements and prey abundance of these marine mammals, the way in which marine mammals select their prey, and the extent of consumption of fish species by other predators in the system.

- <u>Sealworm infection in fish</u>

Transmission of parasites (sealworm) from seal to fish has a significant economic impact on the fisheries sector in many parts of the North Atlantic. The Scientific Committee reviewed the current state of knowledge concerning the life cycle of sealworms. In relation to the influence of seal abundance on the level of sealworm infection in fish, the Scientific Committee concluded that:

- The presence of grey seals or harbour seals may lead to sealworm infection over the entire North Atlantic region; - because of their more limited foraging range, harbour seals could be particularly responsible for high local infection in fish; - sealworm infection in fish is not necessarily directly correlated with seal abundance, as even a few seals can maintain high infection levels in fish in an area.

**The full report of the Scientific Committee will be presented to this year=s annual meeting of the Council of NAMMCO, which will be held in Tórshavn, Faroe Islands from 27- 30 May 1997.**

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