NAMMCO

NAMMCO/6/6

SCIENTIFIC COMMITTEE

Report of the Fourth Meeting[1]

Nordic House, Tórshavn, Faroe Islands
5-9 February 1996

1 The report of the NAMMCO Scientific Committee should not be quoted without prior consultation with the Secretary of NAMMCO.

FOURTH MEETING OF THE NAMMCO SCIENTIFIC COMMITTEE

- CONTENTS -

FOURTH MEETING OF THE NAMMCO SCIENTIFIC COMMITTEE

Tórshavn, Faroe Islands, 5-9 February 1996

SUMMARY OF MAJOR DECISIONS AND RECOMMENDATIONS

1. DECISIONS

External expertise *(8.1.1)*

[....] the Scientific Committee agreed that NAMMCO should, if required, finance the travel costs to the April meeting of the ICES Study Group on Long-finned Pilot Whales for certain scientists whose participation was identified by the Scientific Committe as being important to the successful completion of the Study Group's work.

Review of NASS-95 *(9.2):*

The Scientific Committee agreed to establish a Working Group on Abundance Estimates, under the Chairmanship of Sigurjónsson (Iceland), with its basis in the previous Working Group to plan NASS-95. The task of the Working Group on Abundance Estimates would be to review analyses and where relevant also 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

Monitoring of marine mammal stocks *(10.2)*:

The Scientific Committee agreed that the production of a table showing stock levels and trends in stock levels of marine mammals in the North Atlantic should be coordinated through the Working Group on Abundance Estimates. The table, which would also include pinnipeds, could then be included as an Annex to the List of Priority Species, which should be revised in time for the next Scientific Committee meeting. The table could thereafter be updated at regular intervals in line with the regular revision of general summaries for each species/stock contained in the List of Priority Species.

Data *(11.2 & 11.3):*

With regard to specific questions raised in SC/4/10 concerning standards for submitting data to the Secretariat and the national institutes responsible for the data, the Scientific Committee agreed to appoint one Committee member from each member country to a Data Group. The Data Group would function as the Secretariat's point of contact for clarification and advice on specific requirements for the further development of the database, as well as questions concerning the standards for data submission, storage and handling.

It was ....agreed that references to relevant "grey literature" (ie references not otherwise readily identified through standard catalogues and other reference source), should also be included in the list of references in each National Progress Report.

Publications *(13.3)*:

The Scientific Committee noted the extent to which NAMMCO had initiated and supported the work which formed the basis of the Working Groups' deliberations [on ringed seals and grey seals], as had also been the case with the work on the Atlantic walrus at the last meeting. It was agreed that this work should be published and that NAMMCO's role should be duly recognised in the context of the publication.

[...] the Scientific Committee agreed to seek guidance from the Council on the preferred manner in which to publish the work generated by the Scientific Committee, while stressing the importance of making such work readily available in published form, and ensuring that NAMMCO's role in generating these reviews is sufficiently visible. It was also suggested that in order to aid the Council in its deliberations, the Secretariat could prepare a preliminary analysis of the cost of undertaking a NAMMCO publication series.

2. RECOMMENDATIONS TO COUNCIL

Catch and by-catch data *(5.4 & 8.6.1)*:

The Scientific Committee noted the importance of obtaining data on the level of by-catches for population assessments, and agreed to recommend to member countries to establish a system for reporting data on by-catches.

With reference to the hunting season for grey seals in Norway, the Scientific Committee recommends that a system for recording catch statistics is established as soon as possible, and all NAMMCO member countries are requested to record statistics of grey seals killed at fish farms and in fishing gear.

The Scientific Committee further recommends that all countries with fishing operations within the range of the grey seal establish a system for obtaining and reporting by-catches of grey seals (and other marine mammals).

ICES Study Group on Long-finned Pilot Whales *(8.1.1)*:

[...] the Scientific Committee also agreed to recommend to all NAMMCO member governments to ensure that the necessary scientific expertise is available to the ICES Study Group on Long-finned Pilot Whales.

Harbour porpoise *(5.4 & 13)*:

Noting that the Management Committee, at its first meeting in Tromsø (January 1993) had indicated a long-term interest in the harbour porpoise, the Scientific Committee agreed to recommend to the Council that the harbour porpoise be included on the agenda for its next meeting in 1997, with the view to undertaking a comprehensive review, with input from external expertise, in the near future.

3. RESEARCH RECOMMENDATIONS

Harp seal *(8.3.2)*:

The Scientific Committee noted the recommendations for future work given by the Joint ICES/NAFO Working Group and endorsed these. The Scientific Committee points especially to the need for detailed information on design and techniques used for aerial surveys of harp seals in the White Sea in order to fully evaluate the status of that stock. It is important that age samples are collected from moulting seal catches from the southeastern Barents Sea. These samples are necessary to be able to utilise recaptures of tagged animals for estimating harp seal pup production in the White and Barents Seas based on a mark-recapture estimator. Given the present lack of data, the Scientific Committee pointed to the need for ecological studies of Greenland Sea harp seals.

Hooded seal *(8.4.2)*:

The Scientific Committee noted the recommendations for future work given by the Joint ICES/NAFO Working Group and endorsed these. The Scientific Committee points especially to the need for an abundance estimate of the Greenland Sea hooded seal stock, as well as further studies on ecology.

Ringed seal *(8.5.3)*:

In view of some major gaps in knowledge about ringed seals and their exploitation, the Scientific Committee made the following recommendations:

i) Monitoring of catches as well as studies of loss rates in different types of hunts, the extent of under-reporting, and changes in hunting effort and trade in seal products, should be undertaken in both Greenland and Canada.

ii) Studies are required on the stock identity, productivity and abundance of pack-ice ringed seals, as these seals are believed to help sustain the catches in some areas and may be vulnerable to various human activities other than hunting which occur in the pack ice.

Grey seal *(8.6.4)*:

Abundance and stock levels in the North Atlantic

For proper assessment of abundance and stock levels it is important to have further data on stock identity. The Scientific Committee appreciated the recent information on stock identity made available by analyses of mt DNA and encouraged further sampling for genetic analysis. Further, the Scientific Committee recommends exchange of samples between laboratories on both sides of the Atlantic.

Most abundance estimates are obtained from pup counts. The Scientific Committee recommends full descriptions of the methods used to obtain these estimates, of the statistical properties of the estimates and of actual and potential bias in the estimates. When possible, the Scientific Committee recommends multiple surveys and the establishment of confidence limits with the estimates of pup production. When multiple surveys within years are not possible, the Scientific Committee advises that well defined and described surveys may be used to establish an index of trend in pup production. When surveys are not possible, the Scientific Committee recommends the use of photo-identification techniques.

The Scientific Committee recommends further studies to investigate pup mortality, juvenile mortality, adult mortality, fecundity, age at first reproduction and growth parameters.

The grey seal hunt in Iceland is well documented and provides an example of an annual hunt which seems to have had a significant and clearly detectable impact on the population size and trend. The Scientific Committee recommends that the age distribution of this population is further studied if age samples become available, and that the effect of harvest on demography and population size is documented.

Role in the marine ecosystem

The Scientific Committee recommends the use of satellite linked tags for further studies of distribution of grey seals at sea.

The Scientific Committee further recommends that when diet studies are based entirely on either shot samples or faecal samples, attempts should be made to calibrate the method by comparing ingestion and excretion of identifiable prey in captive seals.

The Scientific Committee noted the limited data on population size, diet and foraging behaviour of grey seals in Norway and Faroe Island, and recommends that studies of these aspects be undertaken.

Nematodal infestation in fish

The complex life cycle of sealworm will complicate any attempt to control infestation levels in fish. The Scientific Committee recommends further studies on the life cycle and population dynamics of the sealworm (*Pseudoterranova decipiens*).

REPORT OF THE FOURTH MEETING OF THE SCIENTIFIC COMMITTEE

Tórshavn, Faroe Islands, 5-9 February 1996

The Scientific Committee of NAMMCO met in the Nordic House, Tórshavn, Faroe Islands from 5 to 9 February 1996. The meeting was attended by members of the Scientific Committee as well as a number of invited experts. A list of participants is contained in Appendix 1.

1-3. OPENING PROCEDURES

The Chairman, Tore Haug, welcomed members and the invited participants to the meeting, including the new member for Norway, Arne Bjørge, who replaced Arnoldus Schytte Blix. The Chairman asked for clarification of current membership from other member countries. Heide-Jørgensen explained that a request had been made to the Greenland authorities to replace Finn Larsen, who was no longer in a position to continue as a member of the Committee. Bloch reported that a third member for the Faroes would soon be appointed. Iceland was represented at the present meeting by two of the three members, all of whom remained as originally appointed.

The Chairman referred to the most recent requests for advice forwarded from the Council which would be the main focus of the present meeting, in particular the requests for review and assessment of ringed seals (*Phoca hispida*) and grey seals (*Halichoerus grypus*). The Chairman welcomed the participation of eight external experts who had been invited by the Scientific Committee to assist in the work of the Committee on these matters. The Committee agreed to establish two separate *ad hoc* Working Groups under the chairmanship of M.P.Heide-Jørgensen (Greenland) for ringed seals and A.Bjørge (Norway) for grey seals, which met simultaneously during the Committee meeting (see below under 8.5 and 8.6).

The Committee was informed of the practical arrangements for the meeting, which included a reception hosted by the Nordic House and a dinner at the National Art Gallery of the Faroes in Tórshavn hosted by the Faroese Museum of Natural History.

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

4. REVIEW OF AVAILABLE DOCUMENTS

Documents presented to the meeting, as listed under item 15, were reviewed. These included National Progress Reports for 1995 from the Faroes, Iceland and Norway, and for 1994 from Greenland (SC/4/NPR - F,G,I & N).

5. COOPERATION WITH OTHER ORGANISATIONS

5.1 ICES

The Chairman referred to document SC/4/14, which listed the requests for advice which have been forwarded by the Council to ICES (a full list of requests for scientific advice, including those forwarded to ICES, is contained in Appendix 3). It was noted that no final answers were yet available from ICES, as these requests were still being addressed in the relevant ICES Study or Working Groups. The Chairman further noted the broad scope of some of these requests and the associated long-term research requirements required to provide comprehensive responses to questions, in particular those regarding contaminants in marine mammals and multi-species approaches.

The Secretary informed the Committee of her recent meeting at ICES headquarters, where information was exchanged and NAMMCO/ICES relations were discussed with the ICES General Secretary, Fisheries Secretary and Environment Secretary. Although formal NAMMCO/ICES relations were normally conducted at Council level, some points had been discussed which were also of interest to the Scientific Committee.

Amongst these was the question of the availability of reports from ICES Working and Study Groups. According to ICES procedure, such reports were not normally available until they had been vetted by the appropriate ICES Advisory Committee. The Scientific Committee noted, however, the importance of having reports from ICES marine mammal-related Study and Working Groups available for information and reference in its own work, and that it should be possible to include such an arrangement for prior availability of these reports in any future formal agreement between NAMMCO and ICES.

With respect to work on developing multi-species models, it was noted that the inclusion of marine mammals in multi-species models was relatively new. It was suggested that greater input from scientists working on marine mammals should be encouraged in the ICES Multi-Species Working Group, where significant work had already been conducted on fish species, such as Atlantic herring and capelin, which were also prey items for certain marine mammal stocks.

The Secretary also reported to the Committee on information received from the ICES Environment Secretary regarding recent ICES involvement in a Working Group on Concentrations, Trends and Effects of Substances in the Marine Environment (SIME) under the Oslo Paris Conventions (OSPAR). ICES would be assisting in addressing the question of whether high concentrations of PCBs in marine mammals disturb enzyme systems. In this connection, the Working Group had identified the outcome of NAMMCO's International Conference on Marine Mammals and the Marine Environment as a source of data on concentrations as well as the development of assessment criteria (see also below under item 14).

5.2 NAFO

Relations with NAFO were largely associated with the request forwarded to both ICES and NAFO on harp and hooded seals, and the ongoing work of the Joint ICES/NAFO Working Group on these species (see below under 8.3 and 8.4).

NAFO and ICES co-sponsored the Symposium on the Role of Marine Mammals in the Ecosystem which was held in Dartmouth, Canada, 6-8 September 1995 (see also below under item 7). The symposium was co-convened by Jóhann Sigurjónsson from Iceland and G.B. Stenson from Canada, and had also been attended by a number of other NAMMCO Scientific Committee members as well as the Secretary.

5.3 IWC

The Secretary informed the Committee of a request received from the Secretary of the IWC on behalf of the IWC Scientific Committee for a copy of the Report of the Working Group on Northern Bottlenose Whales, which met in Copenhagen during the third meeting of the Scientific Committee in a joint session with the Working Group on Management Procedures. The report of the Working Group was contained as an annex to the report of the Scientific Committee, and this was recently published in the NAMMCO Annual Report for 1995. The Annual Report has now been distributed to inter-governmental organisations with whom NAMMCO regularly exchanges information, including the IWC.

5.4 ASCOBANS

The Chairman referred to a letter received from the Secretary of ASCOBANS (Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas) requesting cooperation between NAMMCO and ASCOBANS on exchange of survey data, such as was now available from the 1994 SCANS survey, and future cooperation in survey planning, as well as scientific collaboration on a project to determine the population structure of harbour porpoise in the North Atlantic. It was further suggested that pooling of information on by-catch reporting would also be useful. The letter, together with a copy of the proposal for the harbour porpoise project, were circulated as SC/4/5.

Bjørge, who is a co-author of the harbour porpoise research proposal, informed the Committee that the harbour porpoise population structure project had been endorsed by both the IWC Scientific Committee and ICES. The project was motivated by the fact that harbour porpoises were vulnerable to by-catches in many areas, but there was a need to facilitate greater collaboration in the exchange of data, in particular in the collection of tissue samples, in order to be able to take the project further.

There was general agreement in the Scientific Committee that such collaboration with ASCOBANS would be a positive development. The Scientific Committee noted that considerable data on harbour porpoise was available in Greenland, Iceland and the Faroe Islands, including tissue samples and information on distribution. Sightings data for harbour porpoise were also available from NASS surveys, including NASS-95.

The Scientific Committee agreed to recommend work on the harbour porpoise under NAMMCO (see further under item 13.1 - Future work plans - Scientific Committee).

The Scientific Committee noted the importance of obtaining data on the level of by-catches for population assessments, and agreed to recommend to member countries to establish a system for reporting data on by-catches.

5.5 Other

In response to an enquiry regarding last year's recommendation to establish formal relations with the Canada-Greenland Joint Commission for the Conservation and Management of Narwhal and Beluga, the Secretary reported that official contact had now been established, initially as an agreement between Commissions to exchange reports, including the reports of the Commissions' respective scientific groups.

With respect to the establishment of technical working links with IUCN through its Species Conservation Unit and the Chairs of the Cetacean and Seal Specialist Groups, as reported at the last meeting, the Secretary informed the Committee that these relations had yet to be further developed, but were a priority. In this connection it was also noted that some members of the Scientific Committee were also members of the Cetacean Specialist Group of the IUCN Species Survival Commission.

6. UPDATE OF LIST OF PRIORITY SPECIES

At the last meeting of the Scientific Committee, it was agreed that a process of revision and update of the List of Priority Species should be undertaken prior to the present meeting, coordinated through the Secretariat in consultation with the Chairman, with particular attention to updating and screening catch figures for inclusion in a revised List.

The Chairman noted that this work had not yet been undertaken and urged that the List of Priority Species be updated in time for the next meeting of the Scientific Committee in 1997. It was noted that a considerable amount of new data was now available for most of the priority species, including those which have been the subject of recent comprehensive assessments by the Scientific Committee. The results of NASS-95 would also provide updated abundance estimates for several cetacean stocks, which should also be incorporated into a revised List.

The Chairman would propose a division of species among the relevant Scientific Committee members, who would then be responsible for updating information for the List in time for the next meeting. This work would be initiated and coordinated by correspondence through the Secretariat.

7. ROLE OF MARINE MAMMALS IN THE MARINE ECOSYSTEM

7.1 Update on progress

The Chairman noted that there had been a growing research focus on the role of marine mammals in the ecosystem in recent years. In particular since its last meeting, a considerable amount of new information and published papers had become available.

These included the published proceedings of the International Symposium on the Biology of Marine Mammals in the Northeast Atlantic (Blix et al. 1995). The Chairman noted that many of the papers in this volume had resulted from the Norwegian marine mammal research programme and reflected the major focus on research such as feeding ecology related to the role of marine mammals in the ecosystem.

Sigurjónsson reported on the NAFO/ICES Symposium on the Role of Marine Mammals in the Ecosystem, held in Dartmouth, Canada, 6-8 September 1995 with G.B. Stenson (Canada) and himself as co-convenors. The conveners' report was distributed as document SC/4/6.

The symposium was attended by 113 scientists from 16 countries and a total of 30 oral and 21 poster contributions were presented. The three day symposium was divided into four theme sessions that dealt with: 1) Environmental, spatial and temporal influences of life histories; 2) Foraging strategies and energetic considerations in the diet; 3) Marine mammal-fisheries interactions; and 4) Theoretical considerations on the role of apex predators and multi species models.

A variety of studies related to the main themes of the conference and the discussions which followed centred around modelling of the marine mammal component of the ecosystem and new techniques recently developed that may prove important in the future to improve the understanding of the role of marine mammals in the ecosystem. It was emphasized that it was necessary to include scientists from various disciplines to study a variety of biological and physical components of importance to marine mammals. The temporal/spatial scale at which marine mammals are investigated is not always compatible with the scale at which information from other disciplines is available. This is a matter of concern and it is therefore important that studies on marine mammals are planned in cooperation with studies in other disciplines. Finally, it was noted that in many cases it may not be possible to quantify the interactions precisely. Models incorporating uncertainties in input parameters must therefore be robust but sensitive enough to identify the magnitude and direction of competitive interactions within the system.

Although the symposium fell short in resolving all the complicated questions scientists are facing on the role of marine mammals, it provided a very fruitful forum for exchanges of views. Some of the results reported to the conference are reflected under items 8.3 and 8.4 of this report, while others will contribute to future deliberations of the Scientific Committee on aspects related to the ecological role of marine mammals, including their interactions with fisheries.

7.2 Future work

The Chairman noted that the question of the role of marine mammals in the ecosystem was a vast field of science. He suggested that if this item was to continue to be included on the agenda of the Scientific Committee in the future, then it may be preferable to consider more specific aspects related to the field.

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

8.1 Long-finned pilot whales

8.1.1 Update on progress

It was reported that the ICES Study Group on Long-finned Pilot Whales, which was dealing with matters related to NAMMCO's request for advice on this species, had postponed its scheduled 1995 meeting until 22 - 26 April 1996 in Cambridge.

Desportes and Bloch informed the Committee of progress in finalising the outstanding work required for the Study Group's assessments, as had been identified at the last meeting of the Study Group in Copenhagen in September 1993. It was noted that new sightings data from NASS-95 would also be analysed in time for the Study Group meeting.

The Committee discussed at some length matters related to participation in the ICES Study Group on Long-finned Pilot Whales, in particular the question of funding such participation. After informal discussions with the Chairman of the Scientific Committee and the Chairman of the ICES Study Group in September concerning the importance of ensuring full participation in the next meeting of the Study Group, the Secretary had informed Bloch in writing that travel funding for some Study Group participants would be possible through NAMMCO.

Heide-Jørgensen noted that the Committee must be careful not to set a precedent in the case of the ICES Study Group for funding of nationally-appointed scientists to attend Working Group meetings.

In this connection it was also noted that at its 5th meeting in Nuuk in February 1995, the Council had agreed to the general principle that scientists appointed by member countries as members of Scientific Committee Working Groups should be funded by their respective governments.

Øien noted that although this was meant as a general rule, it was important for the ICES Study Group to finish its work, and that it should be possible for NAMMCO to fund the participation of Study Group members who were not associated with research projects otherwise funded by NAMMCO member countries. Desportes pointed out that all members of ICES Study and Working Groups, regardless of their national affiliations, must be appointed by national delegates of ICES, and that this could not be regarded as equivalent to national members of NAMMCO Scientific Committee Working Groups.

Sigurjónsson suggested that three forms of participation could be defined: 1) Scientific Committee members; 2) Working Group members appointed by member governments to Working Groups; and 3) Working Group members agreed upon by the NAMMCO Scientific Committee.

The Committee agreed that participants in categories 1) and 2) above should not be funded through NAMMCO.

Based on this, the Scientific Committee agreed that NAMMCO should, if required, finance the travel costs to the April meeting of the ICES Study Group on Long-finned Pilot Whales for certain scientists whose participation was identified by the Scientific Committe as being important to the successful completion of the Study Group's work.

Further, the Scientific Committee also agreed to recommend to all NAMMCO member governments to ensure that the necessary scientific expertise is available to the ICES Study Group on Long-finned Pilot Whales.

8.1.2 Future work

The Scientific Committee expressed its hope that the forthcoming meeting of the ICES Study Group on Long-finned Pilot Whales would be its final meeting, and that its report would subsequently provide an adequate basis for addressing the Council's request for advice on this species. The Scientific Committee would return to this again at its next meeting.

8.2 Killer whales

8.2.1 Update on progress

Haug reported that studies were continuing in Norway on killer whale feeding ecology as well as work on sound patterns and photo-identification There was no final data available at present as these studies were still not complete.

Sigurjónsson reported that long-term photo-identification studies of killer whales off Iceland were continuing, and that there were plans to conduct satellite tracking in late 1996.

New sightings data had also been obtained from sightings surveys in the summer of 1995 (NASS-95).

8.2.2 Future work

The Committee noted that no advice could be provided until results from ongoing research on this species were available and data from the most recent sightings surveys had been analysed. The Committee agreed to review further progress on killer whales at its next meeting.

8.3 Harp seals

8.3.1 Update on progress

Øien reported that the Joint ICES/NAFO Working Group on Harp and Hooded Seals had met in Dartmouth, Canada, 5-9 June 1995. The terms of reference as suggested by NAFO were to assess the harp and hooded seal stocks in the Northwest Atlantic as well as the impact of environmental changes and ecological interactions for all Atlantic stocks. NAMMCO's request for assessment advice on harp seals in the White and Barents Seas, and of harp and hooded seals in the Greenland Sea was reiterated to ICES in May and the Working Group also reviewed available information on these stocks.

Satellite tagging data have provided new details on distribution and migration of harp seals, and DNA studies suggest that east and west Atlantic stocks can be discerned. These data do not, however, provide any reason for changing current stock boundaries for harp seals.

At its first meeting in January 1993, the NAMMCO Management Committee recommended to the Council that the Scientific Committee assess the effects of recent environmental changes or changes in the food supply and possible interactions with other living marine resources of harp seals in the White and Barents Seas, and harp and hooded seals in the Greenland Sea and the Northwest Atlantic (NAMMCO, 1993, p. 64). The Scientific Committee noted that the Joint ICES/NAFO Working Group on Harp and Hooded Seals, at its meeting in Dartmouth, Canada, in June 1995, had discussed questions concerning the ecology of seal stocks (SC/4/7a). Further discussions of harp and hooded seal ecology were held during a special meeting following the ICES/NAFO Symposium on the Role of Marine Mammals in the Marine Ecosystem in Dartmouth, Canada, in September 1995 (SC/4/7b).

8.3.1.1 Northwest Atlantic

Stock sizes and trends

As an illustration of the catch levels in the North Atlantic since 1990, harp seal catches in 1994 were (rounded numbers): Landsmen's catches in the southeastern Canada - 61,000; Greenland catches - 45-55,000; the Greenland Sea stock - 8,000; the White and Barents Seas stock - 42,000.

Total harp seal pup production in the Northwest Atlantic was estimated to a total of 702,900 (SE= 63,600) in 1994 using a combination of photographic and visual aerial surveys. This estimate is significantly higher than the 1990 estimate of 578,000 (SE= 38,000) obtained by using similar survey techniques. A population model using a series of pup production estimates, catch-at-age data and age-specific pregnancy rates, was fitted. The model estimated the total population in 1994 to be 4.8 million individuals when pup mortality was set equal to seals older than 1 year, and 4.5 million harp seals when a pup mortality three times that of older seals was applied. Since 1990 the population has been growing at approximately 5% per year. The Working Group accepted the population model as the best available at the time, and based its replacement yield calculations on that model. Using the most recent catch (1994) as basis for the harvesting regime and a pup mortality equal to seals older than 1 year, a replacement yield of 287,000 harp seals was calculated, and the 1996 population was estimated to be 5.1 million.

Ecological considerations

The seasonal distribution and abundance of northwest Atlantic harp seals is not fully known, and it has been necessary to use assumptions to scale diet composition data in order to estimate food consumption in specific areas. It was noted that the species composition and seasonal variations in the diet of the seals is fairly well known in some areas (coastal areas of Newfoundland and West Greenland), not as well documented in others (Gulf of St. Lawrence, offshore Newfoundland, Arctic Canada), and virtually unknown for offshore areas of Davis Strait-Baffin Bay.

The dominant fish species in the food of northwest Atlantic harp seals are capelin and polar cod. A number of other fish species (e.g. Atlantic cod, herring and redfish) and invertebrates (squid, shrimps and pelagic crustaceans) have been found in seal stomachs, but they appear to play a minor role in the overall diet. The majority of fish consumed are 10-20 cm in length.

It was noted that consumption of Atlantic cod, capelin and polar cod had been estimated using a simple energetics model. The total estimated prey consumed by 4.8 million harp seals in the northwest Atlantic in 1994 was 6.9 million tons. Almost half (46%) of the prey consumed were estimated to come from Arctic waters while 40% came from waters off eastern Newfoundland and the remaining 14% from the Gulf of St. Lawrence. Using a diet derived from the average of different diet estimates between 1982 and 1993, the annual estimated consumption by harp seal was 1.2 million tons (95% CI 750,000-1.7 million) of polar cod, 620,000 tons (95% CI 288,000-1.0 million) of capelin and 88,000 tons (95% CI 45,000-140,000) of Atlantic cod in eastern Newfoundland waters. In the Gulf of St. Lawrence they consumed 445,000 tons (95% CI 208,000-727,000) of capelin and 54,000 tons (95% CI 14,000-102,000) of Atlantic cod. These estimates should therefore be considered as preliminary and used with caution.

It was noted that a change had occurred in the seasonal distribution of northwest Atlantic harp seals since the late 1980s. In recent years seals have been arriving in Newfoundland waters earlier, and staying for a longer period of time. In addition, higher numbers have been sighted in offshore areas and in areas not traditionally used. There is also evidence that seals are remaining longer in Greenland waters. Concurrent with these changes, there has been a decline in the reproductive potential and body condition of the harp seals. The latter observations are likely related to the increase in abundance of seals and/or changes in prey availability. The changes in distribution may be due directly to the extensive ice cover observed during the early 1990s, increases in range associated with larger populations, or indirectly due to changes in prey availability. It was noted that the distribution and abundance of capelin and polar cod had changed markedly since the mid 1980s. During the same period, changes in relative importance of the two species in the seal diet were observed. Decreases in water temperatures may have contributed to the changes in prey distribution.

8.3.1.2 Greenland Sea

Stock sizes and trends

Mark-recapture updates of pup production in the Greenland Sea harp seal stock for ten cohorts over the period 1977-1991 were similar to those presented earlier with the exception that the 1991 estimate was increased by about 10% to 65,100 (95% conf. interval 53,600-76,800). Since the revised estimate was within the range of values investigated at the 1993 meeting of the Joint Working Group, it was not felt that the findings would make any change to the 1993 assessments.

Ecological considerations

No information is available concerning the feeding ecology of Greenland Sea harp seals.

8.3.1.3 Barents and White Sea

Stock sizes and trends

For the Barents and White Sea stock there was no new information on stock size. Harp seals tagged as pups in the White Sea have been recaptured in the northern Barents Sea, the Greenland Sea moulting patches, the eastern and southern coasts of Greenland and along the Norwegian coast from Finnmark in the north to Rogaland in the south. The age composition in Norwegian catches of moulting harp seals in the Barents Sea continues to show an under-representation of the year classes 1986, 1987 and 1988.

There seems to have been poor recruitment to the White and Barents Seas stock of harp seals in the late 1980s. This is evident both from the absence of certain year classes in the commercial catches, reduced individual growth rates, increased age at maturity and reduced female fecundity. It was acknowledged that these findings may be related to overall trends in the availability of food resources in the area.

Ecological considerations

Also with reference to the White and Barents Sea harp seal stock, substantial changes that had occurred in this ecosystem during the past 30 years were emphasised. The collapse of two important stocks of potential prey species (Norwegian spring spawning herring in the early 1970s and Barents Sea capelin in the mid-1980s) is particularly likely to have had an impact on the feeding habits of harp seals.

The observed seasonal variations in the condition of adult seals indicate that late summer and autumn, when the stock is usually abundant in the northern parts of the Barents Sea area, are the most intensive feeding periods. The pelagic amphipod *Parathemisto libellula* appears to be the dominant prey from September to mid October when a shift to fish seems to occur. Capelin, to a lesser extent polar cod, are major prey during the autumn. In winter and spring the harp seal stock is usually concentrated in the southeastern Barents Sea and the White Sea. Herring has been found to be the main harp seal prey in these areas in late winter (February). During breeding (March) and moult (April-May) the stores of blubber decrease rapidly, indicating restricted food intake at this time.

Changes in White and Barents Sea harp seal migration patterns have resulted in invasions of seals to coastal areas of northern Norway. These invasions have persisted throughout the period 1978-1995, but with variable intensity. Harp seals sampled in the most intensive invasion years (1987 and 1988) were in poorer condition than harp seals taken in the same period in more normal years. The collapse of the Barents Sea capelin occurred in the mid 1980s. Given the fact that capelin is reported as an important harp seal food item during late autumn and winter, it was considered likely that the seals might have faced a food shortage in late autumn and early winter. The low stock sizes of capelin as well as the herring in the Barents Sea in the mid 1980s, combined with increasing numbers of seals within the population, may have been important factors underlying the particularly large seal invasions in 1986-1988. Observations of effects that could indicate density-dependent responses within the population may also support the hypothesis that food shortage has been a factor contributing to the seal invasions.

8.3.2 Future work

The Scientific Committee noted the recommendations for future work given by the Joint ICES/NAFO Working Group and endorsed these. The Scientific Committee points especially to the need for detailed information on design and techniques used for aerial surveys of harp seals in the White Sea in order to fully evaluate the status of that stock. It is important that age samples are collected from moulting seal catches from the southeastern Barents Sea. These samples are necessary to be able to utilise recaptures of tagged animals for estimating harp seal pup production in the White and Barents Seas based on a mark-recapture estimator. Given the present lack of data, the Scientific Committee pointed to the need for ecological studies of Greenland Sea harp seals.

8.4 Hooded seals

8.4.1 Update on progress

Øien reported that the Joint ICES/NAFO Working Group on Harp and Hooded Seal had reviewed information on three recaptures of hooded seals in the Russian moulting catches north of Jan Mayen, which had been tagged at the Front and in the Davis Strait. The recaptured hoods were 7-9 years old. This might indicate that some hooded seals from the western stock migrate to a moulting region which was previously thought to be used by Greenland Sea hoods only. Despite this, it was concluded that present evidence suggests that the majority of Northwest Atlantic hooded seals moult in the Denmark Strait.

As an illustration of catch levels in the North Atlantic since 1990, hooded seal catches in 1994 were: In southeastern Canada 221; in Greenland around 7,000; the Greenland Sea stock 4,744.

8.4.1.1 Northwest Atlantic

Stock sizes and trends
A minimum pup production estimate of 84,000 (SE= 12,600) for the Northwest Atlantic stock based on a survey conducted in 1990 was available. Illustrative replacement yields were calculated from a Leslie matrix model, but these replacement yields are heavily dependent on choices of natural mortality (both for pups and 1 year and older) and harvest regimes and should therefore be used with caution. For the point estimate of 84,000 pups born, a natural mortality of 0.13 and a pup mortality three times that of 1 year and older seals, the replacement yield for a harvest regime of pups only is 22,900 and for a harvest regime of 1 year and older only, 11,800 animals.

The general distribution and migration patterns of northwest Atlantic hooded seals is reasonably well known, while seasonal abundance in specific geographic areas is not known.

Ecological considerations
It was acknowledged that information about hooded seal diet is rather restricted. The limited information available suggests that some demersal and benthic species, such as Greenland halibut, redfish, Atlantic cod, wolffish and pandalid shrimps, may be important components of the diet in some seasons and/or areas. A preliminary analysis of the consumption by hooded seals in the Gulf of St. Lawrence indicated that their role as predators on some commercially important fish species (e.g. Greenland halibut) may be important.

8.4.1.2 Greenland Sea

For the Greenland Sea stock of hooded seals, no estimate of stock size nor pup production is available. Nor is information available concerning the feeding ecology of Greenland Sea hooded seals.

8.4.2 Future work

The Scientific Committee noted the recommendations for future work given by the Joint ICES/NAFO Working Group and endorsed these. The Scientific Committee points especially to the need for an abundance estimate of the Greenland Sea hooded seal stock, as well as further studies on ecology.

8.5 Ringed seals

8.5.1 Review of status

The Chairman referred to the Council's request for advice on ringed seals which had been forwarded from the Management Committee at the Fifth Meeting of the Council in Nuuk, February 1995. The Scientific Committee had been requested to provide:

> "...advice on stock identity for management purposes and to assess abundance in each stock area, long-term effects on stocks by present removals in each stock area, effects of recent environmental changes (i.e. disturbance, pollution) and changes in the food supply, and interactions with other marine living resources" (NAMMCO Annual Report, 1995, p.23).

The Scientific Committee had contracted relevant expertise in Canada, Greenland, Norway and Russia to ensure that a proper response to these questions could be provided. An *ad hoc* Working Group on Ringed Seals was convened under the Chairmanship of Mads Peter Heide-Jørgensen (Greenland), who presented the Working Group's report to the Scientific Committee. The full report of the Working Group is attached as Annex 1.

8.5.2. Advice on:

i) Stock identity

The ringed seal has a circumpolar distribution in Arctic waters. No genetic studies have been conducted and there is no conclusive evidence of different stocks in the Arctic. However two lines of evidence for stock identity were discussed:

a) Tagging studies in Greenland suggest a large scale mixing of especially young female ringed seals within the Baffin Bay;

b) Various studies indicate that the pack ice habitats in Baffin Bay, Greenland Sea, Barents Sea and western Kara Sea are inhabited by large numbers of ringed seals and that some breeding probably takes place in these areas. However, the discreteness of these pack ice seals was uncertain.

Based mainly on the probability of regular exchange of ringed seals, three provisional geographical areas for assessing the status of ringed seals were identified (see Annex 1, Figure 1):

Area 1: Baffin Bay, Davis Strait, eastern Hudson Strait, Labrador Sea, Lancaster, Jones and Smith sounds.

Area 2: Greenland Sea, east coast of Greenland, west coast of Svalbard.

Area 3: Barents and Kara seas.

ii) Abundance in each stock area

Abundance estimates are only available for small parts of Area 1. The Scientific Committee nevertheless found it useful to extrapolate densities of hauled-out ringed seals for different ice types/habitats to the overall distribution of these ice types. The abundance estimates were further corrected for seals missed during the surveys. A crude estimate of 1,300,000 ringed seals was thus derived for Area 1. No quantitative data on ringed seal abundance could be applied to the two other areas.

Another approach based on polar bear predation on ringed seals was attempted in Area 1 (Annex 1, Figure 2). In this area an estimate of 4,650 polar bears is available and different studies suggest that each polar bear needs the energy equivalent of 40 ringed seals per year. Acknowledging that bears eat other species in addition to ringed seals, it was assumed that 30-36 ringed seals are taken annually by each bear and that other predators take one fifth as many ringed seals as are taken by the polar bears. Available estimates of survival and mortality rates in a stationary population of ringed seals suggest that a standing ringed seal population needed to sustain the predation would be between 700,000 and 1,070,000. Removals by humans would require an additional 420,000 to 530,000 ringed seals for the population to remain stable. This exercise suggested a total ringed seal abundance of between 1.1 and 1.6 million.

iii) Effects on stocks of present removals in each stock area

Compilations of reported catches from Canada, Greenland and Russia were examined. It was agreed that the low catches known from East Greenland, Svalbard and Russia would not raise concerns for the status of the seal population in Areas 2 and 3, since they were likely to be taken from a wide geographical area producing large numbers of ringed seals.

The catches in Area 1 needed to be corrected for losses in different types of hunting and for under-reporting. A crudely corrected estimate of removals in Greenland based on published loss rates and information on the distribution of hunting methods was provided. The revised estimate for West Greenland was 63,311 seals on average per year. To this should be added some amount for under-reporting and an estimate of Canadian removals. No rigorous catch statistics were available from Canada, but it was estimated that approximately 20,000 - 30,000 ringed seals were taken annually in the Canadian settlements in Area 1. Thus, an overall annual catch figure of roughly 100,000 ringed seals in Area 1 was applied. This is roughly 6-9% of the estimated abundance which is close to the published estimates of sustainable yield (SY). Three lines of evidence reinforce the conclusion that catches are probably sustainable:

1) The annual removals of 60-70,000 ringed seals in West Greenland have been maintained for more than a century. Also, much higher catches were made in Canada during the 1960s - early 1980s than have been made in recent years, and the subsequent decline was apparently due to the collapse of the sealskin market.

2) Published estimates of SY all assume catch compositions that are proportional to the distribution of age and sex classes in the population. Catches in West Greenland and Canada consistently have a high proportion of young seals and male seals. This should increase the SY.

3) The very wide and uniform distribution of ringed seals, set against the hunting which is at present conducted on a local level, tends to protect the species against wide-scale over-exploitation.

Even though the present removals are thought to be sustainable, the large harvest in Area 1 warrants further monitoring of removals (including losses) as well as the monitoring of developments in hunting effort and the trade in hunting products.

iv) Effects of recent environmental changes (i.e. disturbance, pollution)

Although human activities are increasing in the Arctic, there was little evidence of effects of disturbances at the population level. The most significant effects may come from collisions by ice-breaking vessels operating in areas with ringed seal birth lairs.

Regarding chemical pollution and ringed seals the Scientific Committee was aware of some available information, almost all of it on pollutant levels in body tissues. Except for some inconclusive experimental work on the effects of exposure to oil, no studies of the effects of chemical contamination on ringed seals have been published. Since ringed seals and other components of the Arctic ecosystem are subject to a global assessment that will be available within the next 1-2 years, it was recommended that NAMMCO should exchange information with organisations that are presently assessing the status of the Arctic environment, such as the Arctic Monitoring and Assessment Program (AMAP).

v) Effects of changes in food supply

No information was available about the effects of changes in food supply on ringed seal populations. The effects of fisheries were considered, but since ringed seals mainly feed on species that are not presently subject to commercial exploitation, no direct conflict was identified.

vi) Effects of interactions with other living marine resources

The most obvious interaction with other marine living resources is the predation by polar bears on ringed seals. It was calculated that a polar bear would require the energy equivalent of approximately 40 ringed seals per year. Ringed seals are, however, not the only prey of polar bears, and information on the year-round diet composition of polar bears is far from complete in most areas. Nevertheless, for Area 1, an attempt was made to calculate the predation by polar bears on ringed seals (see item *ii)* above).

8.5.3. Future work

The Scientific Committee agreed that the assessment of the status of ringed seals in the North Atlantic has taken into account all relevant information that is presently available, and that no further advice on ringed seals would be possible at this stage. In view of some major gaps in knowledge about ringed seals and their exploitation, the Scientific Committee made the following **recommendations:**

i) Monitoring of catches as well as studies of loss rates in different types of hunts, the extent of under-reporting, and changes in hunting effort and trade in seal products, should be undertaken in both Greenland and Canada.

ii) Studies are required on the stock identity, productivity and abundance of pack-ice ringed seals, as these seals are believed to help sustain the catches in some areas and may be vulnerable to various human activities other than hunting which occur in the pack ice.

8.6 Grey seals

The Chairman referred to the Council's request to the Scientific Committee made at its Fifth Meeting in Nuuk, February 1995 to:

> "... review and assess abundance and stock levels of grey seals (*Halichoerus grypus*) in the North Atlantic, with an emphasis on their role in the marine ecosystem in general, and their significance as a source of nematodal infestations in fish in particular" (NAMMCO Annual Report, 1995, p. 23).

The Scientific Committee agreed to establish an *ad hoc* Working Group on Grey Seals, under the Chairmanship of Arne Bjørge (Norway), to address this request. External experts from Canada, Iceland and the UK were invited to assist with the review and assessment of this species. The full report of the *ad hoc* Working Group on Grey Seals is contained in Annex 2.

8.6.1 Review and assessment

i) Abundance and stock levels in the North Atlantic

Grey seals were at one time abundant and widely distributed along the Canadian east coast. Extensive hunting by Europeans resulted in the depletion of the grey seal population by the mid-1800s. By the early 1900s grey seals were still considered to be widely distributed, but there was no particular hunt for them owing to their small numbers. During the 1950s the grey seal in eastern Canada was considered to be uncommon.

Grey seal pup production on Sable Island has been determined by complete enumeration between 1977 and 1990. Counts on Sable Island indicate that pup production has increased from 2,181 pups in 1977 to 9,712 in 1989 at an exponential rate of increase of 12.6% per year. Non-Sable Island pup production estimates have been determined from mark-recapture experiments conducted between 1984 and 1990. Using the best estimates, pup production increased from between 5,200 and 6,700 animals during the mid 1980s to between 8,300 and 10,700 during 1989-90 for an annual rate of increase of 8.8%. In 1993 the total population was estimated at approximately 143,000 seals.

In Iceland there is a directed hunt of grey seals. Grey seals were also hunted in earlier times, but before 1982 records of number of seals killed were unreliable. In 1982 organizations of the fishing industry and fisheries in Iceland started promoting seal hunting, and since that time reliable information on catches is available. Grey seals were first counted in Iceland 1982. In the period 1982 to 1990 the population seems to have been stable or slightly increasing, but since 1992 the population has been declining. The abundance of the grey seal around Iceland is now about 8,000 animals. In 1982 the population was estimated as 12,500 (9,550 - 14,400) animals.

Historical and anecdotal information indicates that grey seals breed in caves around the Faroe Islands. The population size was unknown, but grey seals were subjected to harvesting in former times, as well as a bounty system between 1963 and 1967. A total of 970 seals was reported killed during this period. There is at present no estimate for pup production in the Faroe Islands.

Approximately 40% of the world population of the grey seal breeds around the British Isles. The total population estimate was 108,500 for British grey seals in 1994. In Orkney pup production increased by around 9-10% p.a. between 1984 and 1994. In the Outer Hebrides between 1984 and 1994 pup production has increased by around 5-6% between 1984 and 1994, although in the last two years the increase has been only around 2% a year. In the Inner Hebrides pup production increased by 7.6% a year between 1984 and 1994. The North-East English/South-East Scottish population has increased at 7% p.a.. Pup production has not increased uniformly at all colonies and it would be misleading to extrapolate population size to future years using historical trends.

Figures of pup production are available for all known breeding sites along the mainland coast of northwest Europe, However, most figures are based on single counts. No confidence limits are therefore established for these figures. In most cases in Norway and Russia there are no time series available to evaluate trends in populations. Actual counts provide minimum figures of pup production and the most recent counts of pup production are: 358 for Russia; 473 in Norway; 9 in German; 25 in the Dutch Wadden Sea; and 2 in France.

In Norway there is a hunting season from 1 December to 30 April in areas north of approximately 62°N. Although hunting is known to occur, no system has been established to record effort or catches in this hunt.

In several countries grey seals may be killed legally if they approach fish farms. Numbers of seals shot in order to protect fish farms or standing fishing gear are in some areas believed to be significant, but levels of such kills are virtually unknown. By-catches of grey seals in fishing gear are known to occur. Return of tags indicates that seals less than one year of age are particularly vulnerable to entrapment in fishing gear. Levels of by-catches for grey seals, and for marine mammals in general, are poorly documented.

With reference to the hunting season for grey seals in Norway, the Scientific Committee **recommends** that a system for recording catch statistics is established as soon as possible, and all NAMMCO member countries are requested to record statistics of grey seals killed at fish farms and in fishing gear.

The Scientific Committee further recommends that all countries with fishing operations within the range of the grey seal establish a system for obtaining and reporting by-catches of grey seals (and other marine mammals).

Observer schemes are regarded as the most reliable method to obtain by-catch information. Observer schemes, however, are expensive and difficult in practice in fisheries where a large number of small units are operating. The method for obtaining by-catch statistics should therefore be modified to suit the respective fisheries. However, it is important that methods used to obtain by-catch estimates are well-documented so that the statistical properties of by-catch estimates can be explored.

8.6.2 The role of the grey seal in the marine ecosystem

Information on grey seal diet is available from Canada, Iceland, Faroe Islands, UK, and Norway. However, in order to estimate total fish consumption, information is required on the size, structure and dynamics of the seal population, the geographical and temporal distribution of animals, individual energy requirements, and diet composition.

Consumption of Atlantic cod by the Northwest Atlantic grey seal has recently been examined for the Scotian shelf and Gulf of St Lawrence. Depending on model assumptions, particularly assumptions concerning the seasonal distribution of the grey seal population in Atlantic Canada, cod consumption has increased from less than 4,000 tons in the Gulf of St Lawrence and 1,500 tons on the Scotian Shelf in 1970 to nearly 40,000 tons in 1993, including 17,000 tons in the Gulf of St Lawrence and 17,000 tons on the Scotian Shelf and 4,000 tons in other areas throughout Atlantic Canada. Owing to low biomass estimates, the cod fishery in Atlantic Canada has been closed since 1992. Thus in relative terms the consumption of 40,000 tons of cod by grey seals is significant compared to current harvests by the industry. The impact of this consumption on the recovery of Northwest Atlantic cod stocks is difficult to assess, since more than 80% of this consumption would be pre-recruits to the commercial fishery and it is likely that some compensatory mortality occurs which would reduce the magnitude of this impact.

An assessment has been carried out of the annual consumption of fish by the North Sea grey seal population, which has been compared with the commercial catch. A direct comparison shows that grey seal fish consumption is typically around two orders of magnitude less than stock biomass for any species. In the most extreme case, the upper 95% confidence limit of grey seal consumption of cod is about 6% of the lowest estimate of cod stock biomass in the last decade.

Although annual removals of fish biomass by seals are small on a North Sea wide scale, there may be local areas where seal predation is more significant. The concentration of seal foraging in small areas supports this suggestion.

8.6.3 Grey seals as a source of nematodal infestation in fish

Four genera of anisakine nematodes with fish as intermediate host occur in the stomach or intestine of grey seals. The genera *Pseudoterranova*, *Anisakis*, *Contracoecum* occur in the stomach cavity while the genus *Phocascaris* occurs in the pyloric caeca close to the junction to the stomach. The codworm *Pseudoterranova decipiens* (often also called sealworm) is abundant in grey seals in many areas and larval stages of *P. decipiens* penetrate the intestines of fish and infest the muscle. The easily visible, up to c. 50 mm long worm greatly reduces the commercial value of fish fillets, which is a significant problem for the fish industry in areas where infestation is high. The cost of removing larvae from cod fillets alone was estimated to be in excess of $29 million in Atlantic Canada in 1982.

Although there are four species of pinnipeds found throughout Atlantic Canada, the grey seal is the most important as a vector for the nematode *P. decipiens*. Sexually mature worms have been found in grey seals as young as 3-4 months of age. Worm burdens are linked to size, with males carrying heavier burdens than females, owing to their larger size. Seasonal changes in sealworm burdens have been observed, with declines observed during the breeding season, probably as a result of animals fasting and a second decline observed in late summer. This decline may be linked to a change in diet as grey seals switch to prey with lower infestation levels.

In the 1950s sealworm was found in the fillets of groundfish throughout Atlantic Canada, but the heaviest infections were limited to cod from the southern Gulf of St Lawrence, and inshore areas of southwestern Newfoundland, Nova Scotia and the Bay of Fundy. Surveys conducted during the mid 1980s indicated that sealworm levels had increased in many regions throughout the Gulf of St Lawrence and Nova Scotia. Further increases in worm burdens have been observed in the Gulf of St Lawrence between 1983 and 1990. These increases are believed to be linked to increases in the grey seal population that has been observed since the 1970s. However, high geographical and temporal variability in sealworm levels may be linked not only to the distribution of definitive hosts such as seals, but also to other factors such as variability in water temperature. Surveys to determine nematode abundance in grey seals have shown that mean burdens have increased from 158-700 nematodes per seal between 1948-1956 to more than 1,000 in 1990.

High infestation of sealworm is also reported from Iceland and Norway. In Iceland, geographical and temporal changes in abundance of *P. decipiens* in grey seals seem to be related to changes in diet. A temporal change in grey seal diet from less infested groundfish to the highly infested sculpins results in a tenfold increase in abundance of codworm in seals.

8.6.4 Future work

i) Abundance and stock levels in the North Atlantic

For proper assessment of abundance and stock levels it is important to have further data on stock identity. The Scientific Committee appreciated the recent information on stock identity made available by analyses of mt DNA and encouraged further sampling for genetic analysis. Further, the Scientific Committee recommends exchange of samples between laboratories on both sides of the Atlantic.

Most abundance estimates are obtained from pup counts. The Scientific Committee recommends full descriptions of the methods used to obtain these estimates, of the statistical properties of the estimates and of actual and potential bias in the estimates. When possible, the Scientific Committee recommends multiple surveys and the establishment of confidence limits with the estimates of pup production. When multiple surveys within years are not possible, the Scientific Committee advises that well defined and described surveys may be used to establish an index of trend in pup production. When surveys are not possible, the Scientific Committee recommends the use of photo-identification techniques.

Population models show that seal populations in general are more sensitive to changes in mortality than to changes in fecundity rates. Changes in adult mortality have the largest impact on populations. Hunting mortality may be established from catch statistics, but such statistics are not always available, e.g. catches in the hunting season in northern Norway. The Scientific Committee recommends further studies to investigate pup mortality, juvenile mortality, adult mortality, fecundity, age at first reproduction and growth parameters.

The grey seal hunt in Iceland is well documented and provides an example of an annual hunt which seems to have had a significant and clearly detectable impact on the population size and trend. The Scientific Committee recommends that the age distribution of this population is further studied if age samples become available, and that the effect of harvest on demography and population size is documented.

ii) *Role in the marine ecosystem*

The distribution in space and time of foraging activity is essential for further understanding of the impact of grey seals on marine resources and the marine ecosystem. Such information can be obtained by pelage recognition programmes and satellite tracking of free ranging seals. Where there are by-catches of grey seals in fishing operations, conventional flipper tags may also contribute to this knowledge. The Scientific Committee recommends the use of satellite linked tags for further studies of distribution of grey seals at sea.

Where possible, telemetry studies on foraging grey seals should be combined with studies of diet and food availability. The Scientific Committee further recommends that when diet studies are based entirely on either shot samples or faecal samples, attempts should be made to calibrate the method by comparing ingestion and excretion of identifiable prey in captive seals. The Scientific Committee noted the limited data on population size, diet and foraging behaviour of grey seals in Norway and the Faroe Islands, and recommends that studies of these aspects be undertaken.

iii) *Nematodal infestation in fish*

The complex life cycle of sealworm will complicate any attempt to control infestation levels in fish. The Scientific Committee recommends further studies on the life cycle and population dynamics of the sealworm (*Pseudoterranova decipiens*).

9. NORTH ATLANTIC SIGHTINGS SURVEY - NASS-95

9.1 Review of results

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

> "The 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."

The Chairman requested information from the relevant Committee members on the conduct and results of their respective surveys in 1995.

<u>Norway</u>:

Øien reported that the Norwegian survey (*"NILS 95" - Norwegian Independent Line-Transect Survey* - which was a part of NASS-95) was conducted over the period 5 July to 8 August 1995. Immediately prior to the survey departure, a pre-cruise meeting was held with the participation of cruise leaders to establish procedures to be followed on the ships. The target species for the survey was the minke whale and the survey was therefore especially designed to accommodate analyses developed for that purpose. This involved two independent platforms on each vessel and specific tracking procedures for minke whales. Included in the survey were also distance and angle estimation experiments.

The total survey area covered by Norwegian vessels comprised the northeast part of the North Atlantic north and east of a line approximately from south of Jan Mayen to north of Scotland (see Appendix 5). This area was divided into 18 blocks which were covered by eleven vessels. Each vessel had three or four teams of observers, dependent on available space. Four-team vessels worked around the clock on a 24 hour schedule, while arrangements on the three-team vessels varied according to available light conditions, and alternations between using both or only one platform. The watches were usually based on 6-hour periods.

About 13,500 nautical miles were searched in primary searching mode, i.e. on predetermined track lines under acceptable weather and sighting conditions. In addition, considerable effort was conducted in transits and also on tracklines under conditions which did not fulfill the requirements, most notably reduced visibility due to fog. Except for the blocks in the eastern Barents Sea which received less than 50% of planned coverage, the coverage was generally as planned or better.

The distribution of minke whale sightings from the 1995 survey seems to be somewhat different from that of the 1989 survey. Of particular note were the relatively few sightings made off Kola, which in earlier surveys have had high densities of minke whales. It should however be mentioned that the Kola block received only about 40% of the planned coverage. Further east in the Barents Sea there were apparently more minke whales. There seemed to be generally more minke whales, as well as other large whales, west of Spitsbergen and in the northern part of the Norwegian Sea in 1995 than in 1988-89, while the density around Jan Mayen was low in 1995.

Reports of sightings during the survey were read onto tape in order to obtain a time signal necessary for timing accuracy for the duplicate analysis of the tracked minke whales. All tapes were re-listened and transcribed after the survey and these data as well as covariate data (observer shifts, weather, activity) have been computerized. The analyses of the data are being undertaken by an "Abundance Estimation Group" established under the IWC Scientific Committee with the aim of working towards an agreed estimate of minke whale abundance during the spring 1996. All other whale species sighted during the survey will also be analysed for the potential use in estimating abundances, and this data will be presented in due time.

Faroe Islands:

Desportes reported on the Faroese survey (SC/4/16), which took place from July 3 - August 7, with one vessel surveying an area between southeastern Iceland and western Ireland (see Appendix 5). The target species for the survey was the pilot whale, and the survey was designed to estimate a g(o) value that would be robust to any responsive movement occurring within the observation range, to investigate the existence of "super schools" and to obtain more precise estimates of school size.

The design was based on adoption of passing mode and on using two independent observation platforms, a primary platform and a tracker platform. On the primary platform, observers searched with the naked eye and concentrated their effort to within 1000m of the vessel. On the tracker platform, the trackers searched with binoculars and concentrated beyond 1000m ahead of the vessel, searching the area from which animals could enter the observation zone of the primary platform. They attempted to track the animals via multiple sightings until they had either passed abeam or had been detected by the primary observers. To obtain reliable angle and distance data, the binoculars were equipped with reticles and mounted on rotating monopods passing through an angle board.

When a school of pilot whales was encountered, sub-groups were recorded separately. A delayed closing procedure was used on a random sample of schools to obtain precise school-size estimates.

After closing, a 360° scan was performed to detect the presence of other schools and new schools were closed on.

The tracker platform was specially designed for this survey in order to reduce as much as possible the effect of vessel vibration at cruising speed. The new design resulted in a great improvement in data collection.

The vessel completed 1,630 nautical miles of effective searching effort, of which 64% was covered in Beaufort 3 or 4 (see Appendix 5). About 40% of the available research time was spent on effort.

A total of 458 groups, including 12 identified cetacean species, were observed. The most frequently encountered species were common and white-sided dolphins, pilot and bottlenose whales. The special pilot whale procedure revealed in most cases the presence of other schools in the vicinity of the initial sighting. This may shed some light on the discrepancy between average school size previously observed at sea vs. average size of schools landed in the Faroes.

The pilot whale data, including Faroese, Icelandic and Norwegian data, are being analysed by D. Borchers and colleagues at the School of Mathematical and Computational Sciences, University of St. Andrews, Scotland. They will be presented to the ICES Study Group on Long-finned Pilot Whales.

Iceland:
Sigurjónsson presented paper SC/4/17 which reported on the Icelandic aerial survey conducted in July 1995 from one aircraft allocated by Iceland to the joint 1995 North Atlantic Sightings Survey (NASS-95 - see also Appendix 5). While the general aim of the Icelandic NASS-95 shipboard and aerial survey was to estimate the abundance of fin and minke whales, the aerial component focussed on minke whales in coastal waters. The total number of minke whale primary sightings was 223. Compared to the 1987 aerial survey, the 1995 results indicate an overall, but not statistically significant increase in sightings rate and a possible increase in population size in the area. The paper reported a clear increase in sightings rate in coastal N Icelandic waters, where the rate rose from 1.96 animals/hr in the 1987 survey to 3.46 animals/hr in 1995 (statistically different at 95% level). This is one of the main traditional minke whaling areas in Icelandic coastal waters. It was noted that past aerial surveys have shown a consistent distribution pattern of minke whales, despite great differences in densities between areas.

Based on the number of sightings made by block, assumed mean surfacing rate of 53 exposures per whale per hour, and the estimated effective search area, the total abundance of minke whales in the 1995 survey area has been calculated as 18,783 with the associated CV of 0.10. The CV does not incorporate variance estimate in surfacing rate. The authors suggested further exploration of the data, particularly with respect to effects of different weather conditions on sightings rates and stressed the need for more information on surfacing rates of minke whales.

Víkingsson presented paper SC/4/18, a cruise report from the Icelandic shipboard survey conducted in the summer of 1995 (NASS-95). The design (area coverage and timing) of the shipboard survey took account of the main target species: fin and minke whales. Area coverage was thus similar to the NASS-87 survey with a more northerly distribution than the NASS-89 survey, when sei whales were the main target species (see Appendix 5). 14 species were encountered in a total of 1,514 sightings (5,246 animals) including a single right whale. The fin whale was the most numerous large whale species, followed by humpback whales, which were seen in considerably larger numbers that in the earlier NASS surveys, despite less total effort in 1995.

....

The Chairman thanked the respective members from Norway, the Faroes and Iceland for their presentations on the successful completion of NASS-95 and the current status of data analysis.

The Chairman also noted that the NASS-95 Fund Allocation Group had agreed in April 1995 that the NASS-95 Fund, which had been established by the Council after a recommendation from the Scientific Committee at its last meeting, should be divided between the Faroe Islands (NOK 600,000) and Iceland (NOK 200,000) to assist with the financing of their respective national surveys under NASS-95.

9.2 Future work

The Chairman noted that national surveys under NASS-95 had been successfully carried out and that data analysis from all areas was now under way.

The Scientific Committee **agreed to establish** a Working Group on Abundance Estimates, under the Chairmanship of Sigurjónsson (Iceland), with its basis in the previous Working Group to plan NASS-95. The task of the Working Group on Abundance Estimates would be to review analyses and where relevant also 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 (see also below under 10.2). The work would be initiated by the Working Group Chairman through correspondence, beginning with a preliminary work plan to be circulated to Scientific Committee members in the near future.

10. MULTI-SPECIES APPROACHES

10.1 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:

> "In 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, p. 47).

It was also noted that requirements for monitoring trends in stock levels involved more than just a comparison of abundance estimates from year to year, and would therefore require more detailed consideration.

10.2 Future work

In discussing how best to deal with this request, the Chairman referred to the Committee's decision to establish a Working Group on Abundance Estimates to review the results of NASS-95 (see 9.2 above), as well as plans for a comprehensive update of the List of Priority Species over the coming year (see 6. above). It was noted that this planned work would provide much of the available data necessary for the production of the requested table of stock levels and trends for both cetaceans and pinnipeds.

The Scientific Committee agreed that the production of a table showing stock levels and trends in stock levels of marine mammals in the North Atlantic should be coordinated through the Working Group on Abundance Estimates. The table, which would also include pinnipeds, could then be included as an Annex to the List of Priority Species, which should be revised in time for the next Scientific Committee meeting. The table could thereafter be updated at regular intervals in line with the regular revision of general summaries for each species/stock contained in the List of Priority Species.

11. DATA AND ADMINISTRATION

11.1 Establishment of database

The Committee reviewed document SC/4/10, a report on the establishment of a database in the Secretariat.

The Secretary explained that a fisheries biology student with field and data experience from cetacean research, Atli Konráðsson, had been contracted to assist with the establishment of a database, and that this work had been undertaken since the summer of 1995. The target species for the work were the species currently relevant to the work of the Committee, namely pilot whales, killer whales, northern bottlenose whales, Atlantic walruses, harp seals, hooded seals, ringed seals and grey seals.

As a tool for assessment and management advice for the relevant marine mammal stocks, the report noted that the quality of the contents of the database must be evaluated carefully from a methodological point of view and thoroughly cross-checked technically. The database should contain historical catch statistics and biological data and be updated annually. Routines for submitting data to the Secretariat had not yet been established and were thus open for discussion. Furthermore, data from sightings surveys could serve as indicators of variations in abundance in specific areas and their collection should therefore also be considered. It was also reported that a database of references to papers and publications of relevant biological material had been established in the Secretariat. The report discussed the possibility of establishing a similar database of references to anthropological and sociological literature regarding utilisation of marine mammals.

The report also contained a table summarising the status of catch statistics and biological data in the database by species and country.

Although the basic structure, necessary software and an overview of available data for the database were now in place, there were some outstanding tasks to be completed before the database could be considered fully functional. Particular questions were raised in SC/4/10 for which the Secretariat required further clarification from the Scientific Committee (see below under 11.2). The Secretary asked the Scientific Committee to advise in general on the foreseen function of the database in the future work of the Committee.

The Scientific Committee commended the progress made so far in establishing the database, and encouraged the Secretariat to complete the outstanding work. It was noted that comprehensive data for relevant North Atlantic stocks of marine mammals compiled in the Secretariat would be useful in modelling exercises, such as had been carried out on the northern bottlenose whale stock at the last meeting of the Scientific Committee. In further developing the database, it was noted that particular attention should be paid in the first instance to incorporating all available catch statistics for the relevant species in the North Atlantic, including data from Canada and Russia.

11.2 *Data storage and handling*

With regard to specific questions raised in SC/4/10 concerning standards for submitting data to the Secretariat and the national institutes responsible for the data, the Scientific Committee **agreed** to appoint one Committee member from each member country to a Data Group. The Data Group would function as the Secretariat's point of contact for clarification and advice on specific requirements for the further development of the database, as well as questions concerning the standards for data submission, storage and handling. Members appointed to the Data Group are: Aqqalu Rosing-Asvid (Greenland); Dorete Bloch (Faroes); Gísli Víkingsson (Iceland); and Nils Øien (Norway).

11.3 *Requirements for National Progress Reports*

The Chairman pointed out that the Guidelines for the Content and Format of National Progress Reports, a draft of which had been reviewed by the Committee at its last meeting, had now been slightly revised in line with the Council's preference for a more summarised annual presentation of research from member countries. This new version had been circulated as SC/4/4, and is contained in Appendix 4. The Chairman noted that these guidelines were a useful practical tool for preparing National Progress Reports for submission to the Scientific Committee. No further amendments were suggested.

It was, however, agreed that references to relevant "grey literature" (ie references not otherwise readily identified through standard catalogues and other reference source), should also be included in the list of references in each National Progress Report.

11.4 *Other matters*

The Scientific Committee considered an enquiry from the recent meeting of the Management Committee's Working Group on Inspection and Observation, requesting the Scientific Committee to:

> "... advise whether the elements included on the draft checklist [for inspection] are relevant for scientific purposes, whether any other data of scientific relevance could be added which whalers would be responsible for recording, and to identify the methods of data collection in order to ensure the compatibility of the data recorded." (SC/4/15)

The Scientific Committee noted that the elements previously identified as minimum data requirements (ie position and date of catch, and length and sex of animal) were all included on the proposed draft checklist, and confirmed that these were particularly relevant for scientific purposes.

The Scientific Committee also reiterated its previous response to the question of data collected during whaling operations, which stressed the importance of having more information on the management framework for each species/stock and on the actual procedure for generating advice in order to define specific scientific data requirements.

However, with regard to the question of possible further elements of scientific relevance which could be added to a standard checklist, the Scientific Committee agreed that the collection of skin and tissue samples from each animal would also be useful for scientific purposes, and should be possible in most coastal whaling operations. The collection of other material such as sexual organs and stomach samples, as well as data on body condition, was also identified as relevant.

In addition, it was noted that information included on the checklist under items II & III of the Working Group's draft checklist for recording data on operational activities would also be of scientific relevance with respect to assessments of catch effort.

12. BUDGET

12.1 Review of funds 1995

The Secretary referred to document SC/4/13 which was an overview of Scientific Committee funding in 1995 and projected expenses in 1996. It was noted that a total of NOK 199,413 had been used in 1995 for invited experts and projects, largely in connection with the walrus report prepared for the Third Meeting of the Scientific Committee in Copenhagen in early 1995.

12.2 Budgeted funds 1996

The Secretary informed the Scientific Committee that the forecast 1996 budget adopted by the Council in Nuuk in 1995 (NAMMCO Annual Report 1995, p. 41) contained the same level of total funding for the Scientific Committee (invited expertise and projects) as in previous years. The Secretariat had produced a rough estimate of NOK 300,000 for the projected total costs of invited expertise and projects in connection with work on the ringed seal and grey seal for the present meeting.

With respect to a question raised about the level of fees paid to invited experts for their reports, the Scientific Committee noted that its members were responsible for estimating the amount of time and work required for specific projects, and that this should be considered carefully when agreeing to contract experts to prepare reports for use by the Committee.

13. FUTURE WORK PLANS

13.1 Scientific Committee

It was noted that items for the future work of the Scientific Committee would include matters related to outstanding requests for advice from the Council on long-finned pilot whales, killer whales, and some aspects of the request for advice on harp and hooded seals. Other work related to the role of marine mammals in the ecosystem was still being dealt with in other contexts, but it was suggested that it might be possible to focus on specific aspects related to this field at the next meeting.

Noting that the Management Committee, at its first meeting in Tromsø (January 1993) had indicated a long-term interest in the harbour porpoise, the Scientific Committee agreed to recommend to the Council that the harbour porpoise be included on the agenda for its next meeting in 1997, with the view to undertaking a comprehensive review, with input from external expertise, in the near future.

The Chairman suggested that the next meeting of the Scientific Committee be held in Tromsø, Norway in 1997 at the offices of the Secretariat. The timing of the meeting was discussed, and although it would also depend on the timing of next year's Council meeting, it was agreed that late February/early March would be a suitable time to convene in Tromsø.

13.2 Working Groups

The Chairman noted that the work of the *ad hoc* Working Groups on ringed seals and grey seals was now complete, and these Working Groups were therefore dissolved.

He further noted that a new Working Group on Abundance Estimates had been formed (see 9.2 & 10.2 above), with its point of departure in the former Working Group to plan NASS-95, which was now formally dissolved. The Working Group on Abundance Estimates would aim to hold a meeting prior to the next meeting of the Scientific Committee.

It was also noted that a Data Group had been established, the members of which would liaise with the Secretariat through correspondence to advise on the further development of the database and other matters related to data submission and storage.

13.3 *Other matters*

The Chairman noted the comprehensive work which was the basis for the *ad hoc* Working Groups' reviews of the ringed seal and grey seal at the present meeting, and asked for feedback from Committee members as to the possibilities of publishing this material.

The Scientific Committee noted the extent to which NAMMCO had initiated and supported the work which formed the basis of the Working Groups' deliberations, as had also been the case with the work on the Atlantic walrus at the last meeting. It was agreed that this work should be published and that NAMMCO's role should be duly recognised in the context of the publication.

It was suggested that one option could be for NAMMCO to publish the work under its own name by launching its own publication series, which would also be of interest to the public at large. Another option would be to publish in existing journals which have pre-established subscribers and distribution networks.

With reference to these options, the Scientific Committee agreed to seek guidance from the Council on the preferred manner in which to publish the work generated by the Scientific Committee, while stressing the importance of making such work readily available in published form, and ensuring that NAMMCO's role in generating these reviews is sufficiently visible. It was also suggested that in order to aid the Council in its deliberations, the Secretariat could prepare a preliminary analysis of the cost of undertaking a NAMMCO publication series.

14. ANY OTHER BUSINESS

The Secretary drew the Committee's attention to SC/4/11, a summary report of the International Conference on Marine Mammals and the Marine Environment, which had been organised and hosted by NAMMCO and held in Lerwick, Shetland, 20-21 April 1995. She further informed the Committee that the proceedings of the Conference, co-edited by herself and Geir W. Gabrielsen of the Norwegian Polar Institute in Tromsø, had now been submitted for publication as a special issue of *The Science of the Total Environment*, and would appear as Volume 187/1 in the early summer of 1996.

The Chairman concluded the meeting by commending in particular the Working Group Chairmen, invited participants and Committee members for their valuable contribution to the work carried out in the *ad hoc* Working Groups on ringed seals and grey seals. The Secretariat was also thanked for the organisation and running of the meeting.

Finally, the Chairman, on behalf of all participants, extended his sincere thanks to the Faroese hosts for providing such congenial working conditions and social arrangements for the meeting.

The Chairman closed the meeting of the Scientific Committee at 1930 on Friday 9 February. The final draft of the Report was adopted by correspondence on 1 March 1996.

15. LIST OF DOCUMENTS

SC/4/1	List of participants
SC/4/2	Agenda
SC/4/3	List of documents
SC/4/4	Guidelines for National Progress Reports (Update 1995)
SC/4/5	Request from ASCOBANS for cooperation
SC/4/6	Conveners' Report - ICES/NAFO Joint Symposium on the Role of Marine Mammals in the Ecosystem, Dartmouth 6-8 September 1995
SC/4/7a	Report of the ICES/NAFO Joint Working Group on Harp and Hooded Seals, Dartmouth 5-9 June 1995
SC/4/b	Extract of report of the NAFO Scientific Council Meeting, 9-15 Sept.1995 - VI/8 - Analyses with Respect to the Interaction Between Seals and Commercial Fish Stocks.
SC/4/8	Report of the NAMMCO/SC/WG on ringed seals
SC/4/9	Report of the NAMMCO/SC/WG on grey seals
SC/4/10	Report on establishment of the database in the Secretariat
SC/4/11	International Conference on Marine Mammals and the Marine Environment (Shetland 20-21 April 1995) - Summary of Proceedings
SC/4/12	NASS-95 Fund Allocation Group (minutes of meeting 27.4.95)
SC/4/13	Scientific Committee funding in 1995 and projected expenses in 1996
SC/4/14	List of requests for advice forwarded to ICES
SC/4/15	Request from the Working Group on Inspection and Observation on elements to be included in the Hunter's Checklist
SC/4/16	NASS-95. Preliminary report from the Faroese cruise
SC/4/17	North Atlantic Sightings Survey (NASS-95): Aerialsurvey in coastal Icelandic waters, July 1995.
SC/4/18	North Atlantic Sightings Suvrey (NASS-95): Shipboard surveys in Icelandic and adjacent waters June/July 1995 - cruise report

SC/4/NPR-F	National Progress Report 1995 - Faroes
SC/4/NPR-G	National Progress Report 1994 - Greenland
SC/4/NPR-I	National Progress Report 1995 - Iceland
SC/4/NPR-N	National Progress Report 1995 - Norway

16. REFERENCES

Blix, A.S., L. Walløe and Ø. Ulltang (eds). 1995. *Whales, Seals, Fish and Man*. Proceedings of the International Symposium on the Biology of Marine Mammals in the North East Atlantic, Tromsø, Norway, 29 November-1 December 1994. Developments in Marine Biology 4, Elsevier: 720pp.

North Atlantic Marine Mammal Commission, 1993. *Report of the Second Meeting of the Council*, 65pp.

North Atlantic Marine Mammal Commission, 1995. *Annual Report 1995*, Tromsø, 186pp.

Appendix 1

List of participants

Scientific Committee members:

Faroe Islands

Dorete Bloch
Museum of Natural History
Fútalág 40
FR-100 Tórshavn, Faroe Islands
Tel.: +298 18588
Fax: +298 18589
Email: doreteb@ngs.fo

Geneviève Desportes
Stejlestræde 9, Bregnør
DK-5300 Kerteminde, Denmark
Tel.: +45 65 32 17 67
Fax: +45 65 32 17 76
Email: gene@dou.dk

Greenland

Mads Peter Heide-Jørgensen
Greenland Nature Research Inst.
Tagensvej 135, 1
DK-2200 Copenhagen N, Denmark
Tel.: +45 31 85 44 44
Fax: +45 35 82 18 50
Email: grfimphj@inet.uni-c.dk

Aqqalu Rosing-Asvid
Greenland Nature Research Inst.
P.O.Box 570
DK-3900 Nuuk, Greenland
Tel.: +299 2 10 95
Fax: +299 2 59 57
Email:

Iceland

Jóhann Sigurjónsson
Marine Research Institute
P.O.Box 1390
IS-121 Reykjavik, Iceland
Tel.: +354 55 20240
Fax: +354 5 623790
Email: johann@hafro.is

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

Norway

Arne Bjørge
NINA, P.O.Box 736, sentrum
N-0315 Oslo, Norway
Tel.: +47 22 94 03 71
Fax: +47 22 94 03 01
Email: arne.bjørge@bio.uio.no

Tore Haug
Norwegian Institute of
Fisheries and Aquaculture
P.O.Box 2511,
N-9037 Tromsø, Norwau
Tel.: 77 62 92 20
Fax: 77 62 91 00
Email: toreh@fiskforsk.norut.no

Nils Øien
Institute of Marine Research
P.O.Box 1870,
N-5024 Nordnes, Bergen
Tel.: +47 55 23 86 05
Fax: +47 55 23 83 87
Email: nils@imr.no

Invited experts:

Stanislav Belikov
All-Russian Research Institute
for Nature Protection
Znamemskow-Sadki, Moscow 113 638
Russian Federation
Tel.: +7 095 4230133/311
Fax: +7 095 3232112
Email: arctos@glas.apc.org

Andrei Boltunov
All-Russian Research Institute
for Nature Protection
Znamemskoe-Sadki, Moscow 113 638
Russian Federation
Tel.: +7 095 4230133/311
Fax: +7 095 3232112
Email: arctos@glas.apc.org

Mike Hammill
Department of Fisheries & Oceans
P.O. Box 1000, Mont Joli (Quebec)
G5H 3Z4 Canada
Tel.: +1 418 775 0580
Fax: +1 418 775 0542
Email: m_hammill@am.qc.dfo.ca

Erlingur Hauksson
Icelandic Fisheries Laboratories
Skúlagata 4
IS-101 Reykjavik, Iceland
Tel.: +354 56 20240
Fax: +354 56 20740
Email: erlingur@rfisk.is

Michael C.S. Kingsley
Maurice Lamontagne Institute
Fisheries and Oceans
P.O.Box 1000
Mont-Joli (Quebec)
G5H 3Z4 Canada
Tel.: +1 418 775 0500
Fax: +1 418 775 0542
Email: m_kingsley@am.qc.dfo.ca

Christian Lydersen
Norwegian Polar Institute
Boks 399, 9001 Tromsø
Norway
Tel.: 776 06700
Fax: 776 06701
Email: christian.lydersen@tromso.npolar.no

Randall R. Reeves
Okapi Wildlife Associates
27 Chandler Lane
Hudson, Quebec
J0P 1H0 Canada
Tel.: +1 514 458 73 83
Fax: +1 514 458 73 83
Email: rrreeves@accent.net

Jonas Teilmann
Danbiu ApS
Tornagervej 2
2920 Charlottenlund
Denmark
Tel.: +45 40 53 36 97
Fax: +45 39 63 36 97
Email: danbiu@dk-online.dk

David Thompson
Sea Mammal Research Unit
c/- British Antarctic Survey
High Cross, Madingley Road
Cambridge, CB3 0ET
UK
Tel.: +44 1223 311354
Fax: +44 1223 328927
Email: DTH@wpo.nerc.ac.uk

Bjarni Mikkelsen
c/- Norwegian Institute of
Fisheries and Aquaculture
P.O.Box 2511,
N-9037 Tromsø, Norway
Tel.: 77 62 92 20
Fax: 77 62 91 00

Appendix 2

Agenda

1. Chairman's welcome and opening remarks
2. Adoption of Agenda
3. Appointment of Rapporteur

4. Review of available documents and reports
   - 4.1 National Progress Reports
   - 4.2 Working Group reports
   - 4.3 Other reports and documents

5. Cooperation with other organisations
   - 5.1 ICES
   - 5.2 NAFO
   - 5.3 IWC
   - 5.4 ASCOBANS
   - 5.5 Other

6. Update of List of Priority Species

7. Role of marine mammals in the marine ecosystem

8. Marine mammal stocks - status and advice to the Council
   - 8.1 Long-finned pilot whales
     - 8.1.1 Update on progress
     - 8.1.2 Future work
   - 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 Ringed seals
     - 8.5.1 Review of status
     - 8.5.2 Advice on: i) stock identity; ii) abundance in each stock area; iii) long-term effects on stocks by present removals in each stock area; iv) effects of recent environmental changes (ie disturbance, pollution); v) effects of changes in food supply; vi) effects of interactions with other marine living resources.
     - 8.5.3 Future work
   - 8.6 Grey seals
     - 8.6.1 Review and assessment of : i) abundance and stock levels in the North Atlantic; ii) role in the marine ecosystem; iii) significance as a source of nematodal infestations.
     - 8.6.4 Future work

9. North Atlantic Sightings Survey - NASS-95
   9.1 Review of results
   9.2 Future work

10. Multi-species approaches
   10.1 Monitoring of stock levels and trends in stock levels of marine mammals in the North Atlantic
   10.2 Future work

11. Data and administration
   11.1 Establishment of database
   11.2 Data storage and handling
   11.3 Requirements for National Progress Reports
   11.4 Other matters

12. Budget
   12.1 Review of funds 1995
   12.2 Budgeted funds 1996

13. Future work plans
   13.1 Scientific Committee
   13.2 Working Groups
   13.3 Other matters

14. Any other business

Appendix 3

LIST OF REQUESTS FOR SCIENTIFIC ADVICE FROM NAC/NAMMCO

The following is a list of requests for scientific advice, both from the former North Atlantic Committee for Cooperation on research on Marine Mammals in the North Atlantic (NAC, 1990-1992) and from the Council of NAMMCO since its formation in 1992. Requests which have been forwarded to other bodies (ie ICES and NAFO) are indicated as such.

1. General

Marine mammals and the marine ecosystem:

- To provide an overview of the current state of knowledge of the dependence of marine mammals on the fish and shrimp stocks and the interrelations between these compartments (NAC to ICES)

- To assess the impact of marine mammals on the marine ecosystem, with special emphasis on the availability of economically important fish species (NAMMCO/2).

Multi-species approaches:

- To consider whether multi-species models for management purposes can be established for the North Atlantic ecosystems and whether such models could include the marine mammals compartment. If such models and the required data are not available then identify the knowledge lacking for such an enterprise to be beneficial to proper scientific management and suggest scientific projects which would be required for obtaining this knowledge (NAC to ICES);

- In the multi-species context ... to address specific questions related to the Davis Strait ecosystem such as:
    - the apparent increase in harp seal stocks;
    - its influence on the economically important shrimp and cod stocks;
    - the impact of the fisheries on marine mammals, particularly harp seals;
    - the southward shift of minke whale distribution in recent years, and
    - observed changes in oceanographical conditions after the 1970s;
- and to the East Greenland-Iceland- Jan Mayen area interactions between capelin stocks, fishery and marine mammals (NAC to ICES).

- In 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 (NAMMCO/5).

Environmental issues:

- To describe the possible pathways of radioactive material from blowouts and leakage in existing nuclear power plants, leakage from dumped material and possible accidents in planned recycling plants in the northern part of Scotland into the food web of the North Atlantic and hence into the top predators like marine mammals (NAC to ICES).

- To review the contaminant burden (especially organochlorines) in marine mammals in the North Atlantic and evaluate the possible sources of these contaminants (NAC to ICES).

Management procedures:

- to review the basis for, and develop assessments necessary to provide the scientific foundation for conservation and management of the stocks relevant for management under NAMMCO (NAMMCO/2).

- Further development of RMP-like procedures (NAMMCO/4).

North Atlantic Sightings Surveys (NASS)

- To plan joint cetacean sighting surveys in the North Atlantic by coordinating national research programmes (NAMMCO/3)

- The 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 (NAMMCO/5).

2. Species/Stocks

Long-finned pilot whales:

- To provide an assessment of the state of the pilot whale stock in the north eastern Atlantic, based on the information sampled from the Faroese drive fishery and the NASS sighting surveys (NAC to ICES);

- To analyse the effects of the pilot whale drive hunt in the Faroe Islands on North Atlantic pilot whales (*Globicephala melas*), especially whether the numbers taken are consistent with sustainable utilization (NAMMCO/2).

Harp and hooded seals:

- to assess the stock size, distribution and pup production of harp seals in the Barents Sea and White Sea, and of harp and hooded seals in the Greenland Sea and the Northwest Atlantic;
- to assess sustainable yields at present stock sizes and in the long term under varying options of age composition in the catch;
- to provide advice on catch options in the White Sea/Barents Sea/Greenland Sea and NAFO areas;
- to assess effects of recent environmental changes or changes in the food supply and possible interaction with other living marine resources in the areas (NAMMCO/2 to ICES & NAFO).

Northern bottlenose whales:

- To undertake an assessment of the status of the northern bottlenose whale (*Hyperoodon ampullatus*) stock in the North Atlantic (NAMMCO/2).

- To undertake the necessary modelling of the species as suggested under ... items 9.2. and 10.2.2 of ...[the Report of the Third Meeting of the Scientific Committee, 1993] (NAMMCO/4).

Atlantic walrus:

- To advise on stock identity for management purposes; to assess abundance in each stock area; to assess long-term effects on stocks by present removals in each stock area; to assess effects of recent environmental changes (ie disturbance, pollution) and changes in the food supply (NAMMCO/2).

Killer whale:

- To advise on stock identity for management purposes; to assess abundance in each stock area; to assess effects of recent environmental changes, changes in the food supply and interactions with other marine living resources in each stock area (NAMMCO/2).

Ringed seals

- To advise on stock identity of ringed seals (*Phoca hispida*) for management purposes and to assess abundance in each stock area, long-term effects on stocks by present removals in each stock area, effects of recent environmental changes (ie disturbance, pollution) and changes in the food supply, and interactions with other marine living resources (NAMMCO/5).

Grey seals

- To review and assess abundance and stock levels of grey seals (*Halichoerus grypus*) in the North Atlantic, with an emphasis on their role in the marine ecosystem in general, and their significance as a source of nematodal infestations in fish in particular (NAMMCO/5).

Other - Long-term interest

- Greenland has also indicated a long-term interest in the following species: Harbour seal, harbour porpoise, beluga and narwhal (NAMMCO/2).

Appendix 4

Annotated Guidelines for the Contents and Format of National Progress Reports

(Revised December 1995)

CONTENTS:

I INTRODUCTION

II RESEARCH
- a. Species/Stocks studied
- b. Field Work (e.g. sighting, tagging, scientific catches)
- c. Laboratory work
- d. Other studies
- e. Research results

III CATCH DATA
- a. Pinnipeds
  - Numbers taken
- b. Cetaceans
  - Numbers taken

IV ADVICE GIVEN AND MANAGEMENT MEASURES TAKEN

V PUBLICATIONS AND DOCUMENTS

Annotations:

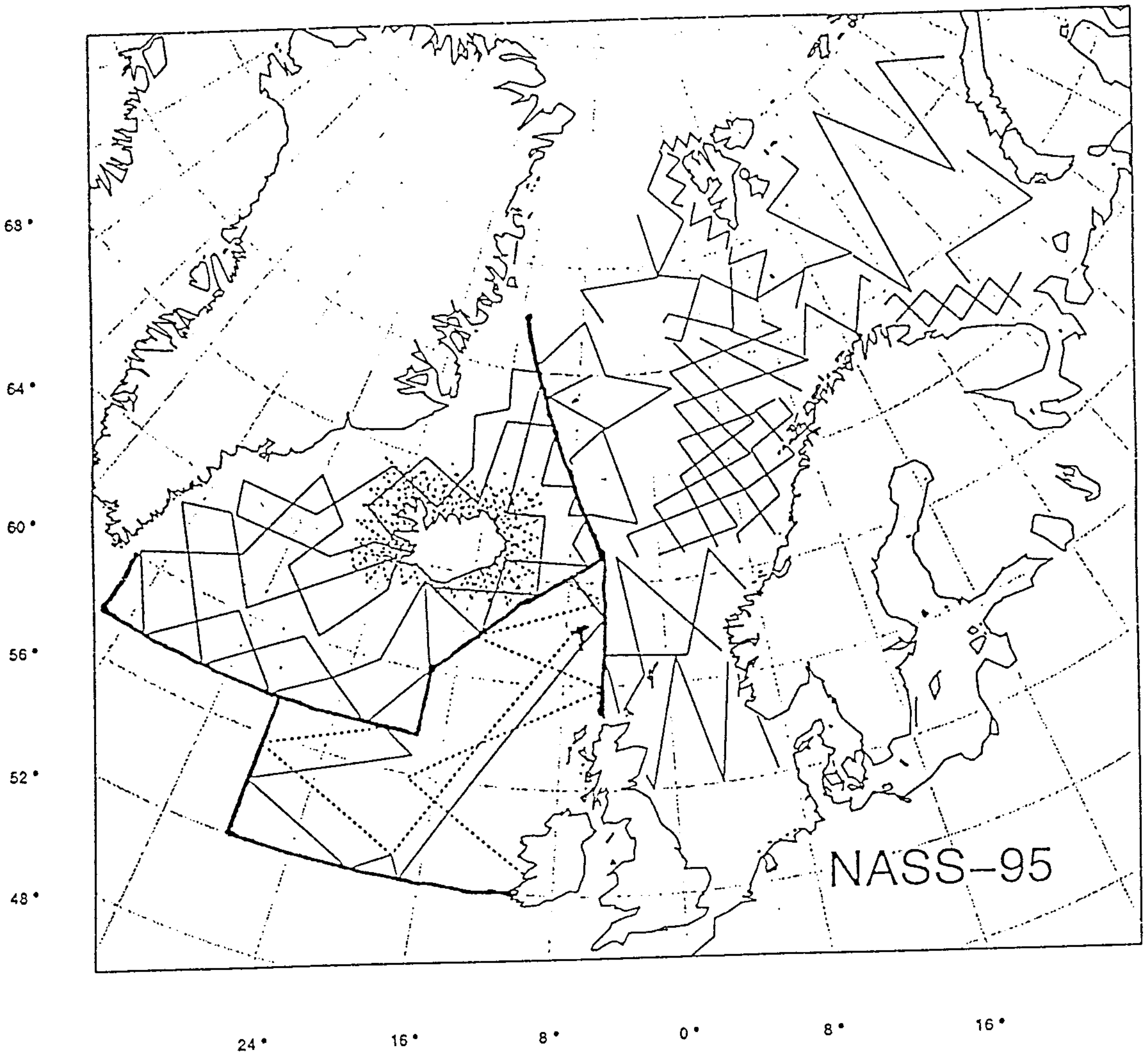
The National Progress Reports should cover the calendar year preceding the annual meeting. A separate Report should be provided for each calendar year. Section I (INTRODUCTION) should indicate which institutions are involved or reported on. Under section II (RESEARCH), items listed under a and b should be addressed. CATCH DATA (III), including number of animals taken should be indicated and tabulated. Under section IV (ADVICE GIVEN AND MANAGEMENT MEASURES TAKEN) the idea is to have reported what kind of management advice (scientific) of relevance for the NAMMCO Council and the Scientific Committee has been provided to the authorities in respective member countries, and, similarly, what management measures have been taken. Section IV (PUBLICATIONS AND DOCUMENTS) should include titles of publications, reports and documents that are likely to be of interest to the work of the Scientific Committee.

Format:

The font should be "Times New Roman", the size in general 12 pt., the introduction 10 pt. and notes connected with tables 10pt.

NORTH ATLANTIC SIGHTINGS SURVEY (NASS) 1995

Scheduled survey track lines: Faroes, Iceland and Norway*



* The map shows the scheduled track lines for NASS-95. The solid bold lines represent the boundaries between the national survey areas (Faroes, Iceland, Norway). The dashed lines around the Icelandic coast show the aerial survey lines (SC/4/17, see also SC/4/18). The dashed lines in the Faroese area show the "secondary cruise track lines" as defined in SC/4/16.

Report of the NAMMCO Scientific Committee *ad hoc* Working Group on Ringed Seals

Torshavn 5-8 February 1996

The *ad hoc* Working Group on Ringed Seals met at the Nordic House in Torshavn from 5 to 8 February 1996. The Working Group was convened and chaired by Mads Peter Heide-Jørgensen. Randall Reeves acted as rapporteur. A list of participants is contained in Appendix 1.

The Working Group referred to the Council's request for advice on ringed seals (*Phoca hispida*) which was as follows:

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

1. Identity of ringed seal stocks in the North Atlantic and adjacent waters

The ringed seal has a circumpolar distribution in arctic marine waters, with disjunct populations in the Okhotsk and Baltic seas and in several freshwater lake systems (SC/4/RS/3). No zoogeographical barriers are known to prevent marine ringed seals from being panmictic. Focussed research on questions related to stock identity of ringed seals has not been done, and no firm evidence of different stocks is available.

Kingsley (SC/4/RS/7) offered a conceptual model for the structuring of the aggregate world population of ringed seals. This model rests on a dichotomy between 'producing' areas and 'consuming' areas. Annual fast ice with good snow cover is prime breeding habitat. Subadults tend to be excluded from the breeding ice by aggressive adults. This means that the subadults mainly inhabit ice edges, polynyas and loose ice areas. Polar bears tend to prefer ice edges and moving (pack) ice for hunting, which means that a high proportion of the seals killed by polar bears are subadult ringed seals (mostly <2 yr old; Stirling & Øritsland 1995). Producing areas provide surpluses of young ringed seals which are consumed by polar bears in what are thus called consuming areas. Kingsley's model is in most respects consistent with McLaren's (1958a) idea that coastline complexity is a major determinant of variability in ringed seal production.

In the absence of conclusive evidence for stock definition, the Working Group reviewed available tag-recapture data as well as the scant, inconclusive evidence of morphological, behavioural and ecological differences in ringed seals from different areas.

a) *Tag returns*

A tagging program in the eastern Beaufort Sea and Amundsen Gulf, Canada, during the early 1970s resulted in a very low tag recovery rate (1.7%) but generally corroborated the opinion of hunters that young seals disperse westward across the Beaufort Sea to at least as far as Northeast Russia (Smith 1987). Maximal distance from the site of tagging to the site of recapture was 1334 km (Smith 1987). Five tagging experiments have been carried out in Greenland since the mid 1970s (SC/4/RS/6). The tag recovery rates were much higher (43% overall) than in the western Canadian study. Young ringed seals (< 5 yr of age) were shown to travel among North, Northwest and Central West Greenland and between NW Greenland (Upernavik) and NE Baffin Island (Clyde River), but most of those that were recaptured were found within 200 km of the tagging site. Satellite tracking of three young males tagged in the fast ice of Wolstenholme Fjord, NW Greenland, in June-July 1988 showed that they moved later in the summer and autumn both northward to Kane Basin and southward into Baffin Bay (Heide-Jørgensen et al. 1992). In addition, a time-depth recorder that had been attached to a ringed seal near Resolute in the Canadian High Arctic (74°30'N, 94°00W) in April-June 1991 was recovered (opportunistically) in March 1992 in Southwest Greenland (Narsalik, 61°30'N, 49°30'W) (SC/4/RS/6). This seal had travelled at least 2272 km, having crossed Davis Strait, during the intervening 9-11 months.

On balance, the limited data from tag-recapture indicate that some young ringed seals from W Greenland disperse over substantial distances but also that many of the young seals either remain within or return to W Greenland. Among the tagged animals, females seemed to disperse more widely than males.

A distinctively marked adult male was resighted in the same locality in SE Baffin Island in successive years (Smith & Hammill 1981), and another adult male that was tagged in the fast ice of Kongsfjorden, Svalbard, was killed in the same area three years later (Lydersen pers. comm.).

b) 'Pack ice' and 'fast ice' populations in Baffin Bay

Finley et al. (1983) considered that seals in the pack ice (=drift ice in Russian nomenclature) of Baffin Bay were 'reproductively isolated' from fast ice seals, based mainly on two lines of evidence:

i) Inuit in N and E Baffin Island recognize two distinct types of ringed seal - one that originates in the fast ice (called *tuvamiutaaq*) and one that enters the fjords after break-up and moves offshore during freeze-up (*pulajuraaq* or *pulaniit*) (Finley et al. 1983). The offshore (pack ice) seals are smaller than the coastal (fast ice) seals. Similar size differences have been noted in other areas including NW Greenland (Vibe 1950), Jones Sound (Rosing-Asvid pers. comm.) and the Okhotsk Sea (Fedoseev 1975).

ii) 'Pack ice' seals were less heavily infected with gastric nematodes than were those of 'fast ice' seals. Finley et al. (1983) inferred that this difference reflected different diets, with seals in the pack ice preying mainly on pelagic amphipods and seals in the fast ice eating mainly arctic cod.

The other evidence evaluated by Finley et al. (1983) was inconclusive. Several members of the Working Group noted that the observations cited by Finley et al. (1983) were open to differing interpretations. Lydersen, for example, reported that small, weaned ringed seal pups (5-10 kg) found in the loose ice in Kongsfjorden are probably animals that were born in the fast ice but were weaned prematurely. The case for a 'distinctive' or 'reproductively isolated' pack ice population in Baffin Bay remained unproven. Although it was recognized that substantial production of ringed seals could occur in the stable pack ice of Baffin Bay, as it could, for example, in the pack ice of the Greenland Sea (Dietz et al. 1985) and Beaufort Sea (Lentfer 1972), the implications for stock identity were not sufficiently clear.

Based mainly on the probability of regular exchange by ringed seals, the group identified three geographic areas for discussion (Figure 1). Area 1 is centered in Baffin Bay and Davis Strait and includes eastern Hudson Strait and the Labrador Sea to the south, and Lancaster, Jones and Smith sounds to the north. Area 2 is centered in the Greenland Sea and includes the east coast of Greenland and the west coast of Svalbard. Area 3 is centered in the Barents and Kara seas. The relatively low biological productivity of the Laptev and East Siberian seas, as well as the ice massif in the central East Siberian Sea, probably limit the amount of movement by ringed seals across northern Russia (Belikov pers. comm.). There may, however, be some exchange via polar routes as ringed seals and polar bears are present year-round as far north as the pole (Durner & Amstrup 1995; M. Ramsay pers. comm. cited in SC/4/RS/3; Belikov pers. comm.).

2. Estimates of abundance

Most surveys of ringed seals have been designed with the idea of estimating densities for studies of seal ecology rather than for population assessment. The only portion of the North Atlantic where extensive surveys of ringed seals have been conducted is the Canadian Arctic (SC/4/RS/3 and 7). Of particular interest in the present context are aerial strip surveys conducted by LGL (Miller et al. 1982) during the late 1970s. Finley et al. (1983) used density estimates for different ice types (pack ice: 1.39 seals/km^2; shelf fast ice: 1.31/km^2; fjord fast ice: 1.72/km^2) from these surveys, along with estimates of the respective amounts of ice area, to make uncorrected estimates of 67,000 ringed seals in the fast ice bordering the east coast of Baffin Island and 417,000 in the Baffin Bay pack ice during late June-early July 1979. After correction factors for availability and detection bias were applied, the pack ice estimate was corrected to 787,000 seals. Using the same method (including the density estimates and correction factors from W Baffin Bay), Miller et al. (1982) estimated that at least 185,000 additional ringed seals inhabited the fast ice along the west coast of Greenland.

Rough calculations were made using information from the literature on seal densities and ice areas in Area 1 (Table 1). These calculations suggest a total standing population in the order of 1.3 million ringed seals in Area 1. Many uncertainties were associated with this approach, and the total figure should be regarded as only a very crude approximation. The ice areas were taken from several different sources, with all fast ice allocated to one of two types - fjord and shelf. It was assumed that the estimated densities for the fast ice were of breeding adults and young of the year, even though it was recognized that due to the timing of the surveys some subadults may have been counted. It was assumed that surveys in the pack ice sampled all age classes. The densities of 1.7 seals/km^2 for all fjord fast ice, 1.3 for all shelf ice except that in western Jones Sound and Kane Basin and 1.3 for all pack ice are based on observed densities in late June/early July 1978-79 in NW Baffin Bay (Finley et al. 1983, their Table 1). The considerably lower density of 0.33 seal/km^2 for western Jones Sound and Kane Basin is a mean value for late June 1980-82 (Kingsley et al. 1985, their Table 13, stratum 1). It should be noted that the inclusion of Ungava Bay pack ice is entirely speculative; no survey data from this area was examined. The raw estimates in the last column of Table 1 were corrected by assuming that, on average, one seal was missed for every one sighted during surveys (see Stirling & Øritsland 1995 for a discussion and rationale).

In evaluating the sensitivity of these calculations, it was noted that the contribution by pack ice is roughly two thirds of the total. Thus the uncertainties associated with the estimated area, seal density and correction factor for the pack ice are particularly critical. The correction factor is, by itself, critical because it is applied to all areas and density estimates, and a relatively small change in it would substantially increase or decrease the abundance estimate. The total abundance estimate obviously refers to the annual post-pupping peak.

Smith & Lydersen (1991) extrapolated observed densities of birth lairs in two types of breeding habitat, 2.6/km^2 near glacier fronts and 0.98/km^2 on flat fjord ice, to the respective total estimated areas of these two habitat types throughout the archipelago, to estimate annual production of 19,500 pups in Svalbard. The dispersal pattern of these seals is not known, but they would presumably represent a total population of about 100,000 seals.

In western Russia, the only quantitative data on ringed seal numbers is derived from work by Lukin in the White Sea. Based on his observed densities of birth lairs in a portion of the White Sea, an extrapolation to the fast ice area considered suitable for breeding gave an estimate of 9000-10,000 adult females between the White Sea and Vaigach Island (Belikov pers. comm.). This would suggest a total population in the order of 50,000 seals. No data were available for Novaya Zemlya, Franz Joseph Land or the Kara Sea.

Several authors have attempted to obtain rough estimates of ringed seal population size by reference to polar bear population size. Kingsley (1990), for example, estimated that each of 15,000-20,000 bears in the Canadian Arctic needed 40 ringed seals for annual maintenance and growth, leading him to suggest that some 4 million ringed seals would be needed to sustain both the bears and human hunters in Canada. He also concluded that polar bears consumed approximately 10 times as many ringed seals as were caught by Canadian Inuit. Stirling & Øritsland (1995) examined a series of bear and seal population estimates from Canada and concluded that the correlation was sufficiently robust to allow the prediction of one by reference to the other. They also investigated more closely the energetics approach used earlier by Kingsley and concluded that each bear, on average, required 43 ringed seals per year. Born (SC/4/RS/5) re-examined the data and approach used by Stirling & Øritsland. He called attention to the fact that predators in addition to bears and people contribute to ringed seal mortality and to the fact that polar bears prey upon other species in addition to ringed seals (these uncertainties were also recognized by Stirling & Øritsland). Born also noted that the slope of the regression line chosen by Stirling & Øritsland (1995) suggested that a population of 222 bears would be sustained by zero ringed seals, which is implausible. Rosing-Asvid pointed out that new estimates of polar bear populations (provided by fax from Born), not available to Stirling & Øritsland, would have severely affected their conclusions.

In Svalbard at least, other seal species like bearded and harp seals are taken regularly by polar bears (Lønø 1970; Lydersen pers. comm.). Thus, Lydersen made some calculations of the energy value of a bearded seal in comparison to a ringed seal. He concluded that a polar bear could be maintained for a year from the fat of only 4.4 adult bearded seals. This means that even if a bear took only one or two bearded seals per year, its requirement for ringed seals would be dramatically less than assumed by Kingsley and by Stirling & Øritsland.

No practical value was seen in attempting to make global estimates of ringed seal populations by reference to polar bear populations. In view of the known heavy reliance of polar bears on ringed seals throughout much of Area 1 (Stirling & Øritsland 1995), however, the group thought that it would be worthwhile to explore a model based on polar bear energy requirements, however fraught with uncertainty such a model might be (Figure 2). This exercise provided an estimate of ringed seal abundance in the same order of magnitude as that obtained from survey data and estimates of ice areas (Table 1).

3. Review of reproduction, mortality and recruitment rates

Reproductive rates (defined as annual pup production as a percentage of the total population) in the literature are generally in the range of 16-24% although there can be wide variation between years (SC/4/RS/3). Estimates of total mortality summarized by Miller et al. (1982) were in the range of 8-20%. Most estimates of sustainable yield (SY) in the literature are in the range of 7-9% (SC/4/RS/3). The group regarded 8% as a reasonable estimate of SY, based on work in eastern Canada.

Kingsley noted the importance of knowing more about how often and for what cause(s) reproductive failures occur in ringed seal populations, e.g. those documented in the early to mid 1970s and again in the late 1980s in the eastern Beaufort Sea/Amundsen Gulf region (Smith 1987; Kingsley & Byers 1990; Harwood & Stirling 1992). In this connection, Kingsley called attention to the apparent plasticity of the ringed seal's reproductive capability. The average age at first reproduction seems to vary by as much as 3 years (4-5 yr to 7-8 yr), judging by evidence from the Beaufort Sea and Amundsen Gulf. This variability presumably indicates an immediate response to annual changes in biological production related to ice conditions (Kingsley, pers. comm.).

Teilmann called attention to the high proportion of males in the ringed seal catches in Greenland (59% overall), which seems to apply to all age classes, all areas and all hunting methods (SC/4/RS/6). He suggested that this subject be investigated further by analyzing the large sample of ringed seal material available (from some 8000 animals) and also by evaluating catch compositions in other areas.

4. Past and present removals in Greenland, Canada, Svalbard and Russia

Statistics on catches of ringed seals in Greenland are available as far back as 1862. No proper validation of the statistics has been conducted. However, the correlation is reasonably close between reported catches and the fur trade statistics, and trends in the catches from adjacent areas are generally consistent. These observations can be taken as evidence that the catch statistics are reliable (SC/4/RS/6). During recent decades catches seem to have fluctuated synchronously in different areas, suggesting that the reported values reflect overall trends. Despite the usefulness of the statistics it is evident that some underreporting can be expected and that the reporting efficiency has changed and the system has periodically been less reliable. During the 1980s the system deteriorated severely. Although the new reporting scheme established in 1992 is believed to be working well, its comparability with the old system is not clear.

The overall mean of catches in Greenland between 1954 and 1994 was 63,250 ringed seals/year, of which 46,500 were in West Greenland (SC/4/RS/6). There has been an overall increasing trend during this period, with a peak in the late 1970s followed by a decline. The apparent decline during the 1980s and 1990s may be real, but it could also be the result of reduced efficiency of the catch reporting system. For comparison, Teilmann pointed out that an annual total catch of 51,000 ringed seals per year was estimated for West Greenland (not including Avanersuaq area) during the 1850s (Rink 1852-57).

In Greenland ringed seals are shot in open water in summer and fall or from the ice edge in spring, netted in open water in fall or in ice in winter, or shot when hauled out on the ice in spring (SC/4/RS/6). Some information is available from Upernavik from the mid 1970s on the distribution of catches made using different types of hunting methods (51% netted, 19% shot in open water, 11% shot at the ice edge and 19% shot while hauled out on fast ice). Loss rates varied according to the hunting method, so catches should be corrected according to how the catch is allocated to different hunting methods. Ideally, correction factors should also be made by area to account for geographic differences. Information on losses in Greenland and Canada were reviewed by Miller et al. (1982), and average values from their review were used here to correct the catch in Greenland (from SC/4/RS/6; Table 2). The catches in NW Greenland (i.e. Upernavik and Uummannaq) constitute 54% of all catches in West Greenland. No information was available on the proportions of the catches made by different methods in N Greenland (Avanersuaq), CW Greenland (Disko Bay area) or the two regions in East Greenland, so loss rates from NW Greenland were applied to these areas in the same ratio as that for NW Greenland. In SW Greenland ringed seals are shot almost exclusively in open water, so the loss rate for this method was applied to the entire SW Greenland catch.

Average loss rates were 30.6% for shooting in open water, 31.7% for shooting at the ice edge and 12.2% for shooting seals hauled out on fast ice. No information was available on loss rates for netting, but very little loss is likely to be associated with this method so the loss rate for netting was assumed to be zero.

The total average annual removals in West Greenland between 1980 and 1994, adjusted for hunting loss in the manner described above, are estimated to be 63,311 ringed seals (Table 2).

No sustained system for recording catches of ringed seals exists in Canada. Short-term regional 'harvesting studies' and series of official trade and fur export records provide some insight into the catches of ringed seals in the past few decades (SC/4/RS/3 and 7). The average figure per settlement on Baffin Island is probably around 2,000 ringed seals per year, which adds up to 20-30,000 in total for the settlements judged to be taking Area 1 seals. No trends in catches are evident from the statistics except that a major decline in the hunting of ringed seals occurred after the sealskin market crash in the early 1980s (Stewart et al. 1986). A substantial but uncertain proportion of the Canadian hunt is conducted during the open water season, when large losses are expected. However, no rigorous estimates of loss rates are available from Canada. Little or no netting of seals is done in the Canadian Arctic today.

Combining the estimated removals in West Greenland with the crudely estimated annual catch in eastern Canada gives a total annual removal of 83,000-93,000. Some allowance must be made for under-reporting and for undocumented and unestimated losses associated with Canadian catches. A provisional estimate of the total annual removals from Area 1 is thus in the magnitude of 100,000 ringed seals.

The average catch for East Greenland is about 13,500 per year, including the loss rates (Table 2).

Recent catches at Svalbard are in the low hundreds (Lydersen pers. comm.) but no proper statistics are collected.

In the Kara Sea ringed seals are shot in spring at the ice at several settlements along the coast primarily for dog food and human consumption. Only limited numbers of ringed seals have been traded commercially in recent years (SC/4/RS/6). Most of the ringed seal catch reported from the White and Barents seas nowadays consists of seals taken as a by-catch in the net fishery for navaga (saffron cod) in the autumn. Only a small portion are shot. The present level of reported catches in the western Russian Arctic totals less than 5000 ringed seals per year. The mean annual reported catch in the White Sea has declined progressively from 6126 during 1903-31, to 2868 during 1960-78 and to 802 during 1985-94. The catch in the Kara and Barents seas has declined from 3305 during 1960-78 to 386 during 1985-92 (SC/4/RS/6). These trends are probably due both to a real decline in catches and to a deteriorating catch reporting system.

5. Predation by polar bears and other mortality factors

Polar bears are by far the most important predators of ringed seals. It is generally agreed that 40-50 ringed seal equivalents are required to feed one polar bear per year and that ringed seals comprise a high proportion of the polar bear's diet in most regions. With a world-wide polar bear population of 20-40,000 bears, this means that ringed seal mortality caused by polar bears is significant. It is important to recognize, however, that ringed seals are not the only prey of polar bears, and the actual magnitude of polar bear predation on ringed seals should be estimated on an area basis.

Other predators on ringed seal pups include arctic foxes, wolves, glaucous gulls, red foxes, dogs, ravens and wolverines, of which arctic foxes are the most important (see Smith 1976). Walruses, killer whales and Greenland sharks prey on older seals as well as pups. Walruses are known to take many ringed seals in certain deep water areas (Lowry & Fay 1984). Data are insufficient for quantifying the importance of any of these predators.

A rabid ringed seal, presumably infected by an arctic fox, has been found in Svalbard (Ødegaard &

Krogsrud 1981). Other areas have rabid foxes as well but no other reports exist of rabies in arctic ringed seals.

Antibodies to Phocine Distemper Virus have been found in 4 (2 weak reactions) out of 90 ringed seals in Greenland, but no signs of the disease have been reported (Dietz et al. 1989). There is little risk of viral epizootics like rabies and PDV becoming major mortality factors in ringed seals. Their generally solitary behaviour makes lateral dispersal of disease unlikely.

Ringed seals are hosts for a number of parasites, primarily gastric nematodes, nematodes in the respiratory tract and trematodes in the gall bladder; Trichinella has been detected once in E Greenland. There are no published reports of parasites contributing to mortality in ringed seals, but lungworms may be an important mortality factor for pups (Hammill pers. comm.).

6. Impact of present removals on stocks

For Area 1 the best estimate of ringed seal abundance is 1.3 million seals (Table 1). An overall figure for annual removals is in the order of 100,000 (Table 1), or roughly 7-8% of the estimated abundance. Although this percentage is very close to the published estimates of sustainable yield (SY), three lines of evidence can be used to suggest that the catches are sustainable:

i) Annual removals in the order of 60-70,000 have been maintained in West Greenland for more than a century (SC/4/RS/6). Similarly high catches were made in Canada (all areas, including the western Canadian Arctic, Hudson Bay etc.) during the 1960s-early 1980s, after which catches apparently declined in all areas due to the collapse of the sealskin market (SC/4/RS/3 and 7).

ii) Published estimates of SY assume that catch composition is proportional to the population age and sex structure, whereas catches in Greenland and eastern Canada consistently have a higher proportion of young seals and a preponderance of males. This catch composition should have the effect of increasing the SY.

iii) The ringed seal's very wide and rather uniform distribution, set against the fact that hunting is limited to particular areas near Inuit settlements, can be seen as tending to buffer the species against wide-scale overexploitation.

On the other hand, it is important to bear in mind that random mixing of ringed seals throughout the region has been assumed but not proven, so the possibility of local overexploitation cannot be ruled out. Even though present removals are probably sustainable, the large harvests in parts of Area 1 warrant further monitoring of removals (including losses) as well as the monitoring of developments in hunting effort and of the trade in hunting products.

Present levels of removals in East Greenland, Svalbard and Russia raise no concern for the status of seal populations, since catches are small and likely to be taken from a wide geographical area producing large numbers of ringed seals.

7. Anthropogenic impacts other than hunting (i.e. disturbance, pollution, fisheries)

The Working Group considered the possible impact of fisheries on ringed seals but found limited evidence of direct competition between ringed seals and fisheries. This is due to the fact that ringed seals feed mainly on species that are not commercially exploited at present (e.g. amphipods and ice-associated cods). In the western Russian Arctic competition may exist between ringed seals and commercial fisheries for navaga (saffron cod), herring and Atlantic salmon (Popov 1982), and there is a by-catch of ringed seals in the navaga fishery (Belikov and Boltunov pers. comm.). These potential problems have not been investigated recently.

Human activities are generally increasing throughout the Arctic and many of these activities potentially disturb ringed seals. These include helicopter traffic, ice-breaking marine traffic, seismic surveys, hydrocarbon exploration and production, trawling, snowmobiles (skidoos) and low-flying aircraft. The working group was aware of several studies addressing questions about the effects of disturbance on individual seals (SC/4/RS/3), but these disturbance studies have not demonstrated population-level effects. The most significant impact may come from collisions by vessels operating in the same ice that is used by ringed seals for birth lairs. Seismic surveys and exploratory drilling have taken place in Svalbard during the past ten years (Lydersen pers. comm.) and similar work is planned in the Pechora Sea (Belikov pers. comm.). In the latter area, there is concern that the hydrocarbon exploration and development will be in one of Siberia's most productive areas for ringed seals (SC/4/RS/8). Also of concern is the opening of the Northern Sea Route to year-round industrial and commercial traffic, which in winter and spring will follow the edge of the fast ice (Boltunov pers. comm.).

Levels of pollutants (organochlorines, heavy metals and radionuclides) have been measured in ringed seals in Canada, Greenland and Svalbard (SC/4/RS/3), but the Working Group was not aware of any studies of physiological effects of pollutants (other than oil) on arctic ringed seals. In view of the large human consumption of ringed seal products in hunting districts, more thorough and comparable investigations are desirable. Some of these are underway. The Arctic Monitoring and Assessment Program (AMAP) will, within the next one or two years, provide results from a large-scale circumpolar study of contaminant levels in ringed seals and other organisms as well as a survey of past measurements. Several Norwegian/Russian projects are in the process of being developed for studying pollutant levels and pathways in biota, sediments and water along the western Siberian coast where river outlets deliver pollutants from industrial and mining activities into the Arctic Basin. The Working Group considered it unwise to attempt an assessment of ringed seals and pollutants until the results of these large-scale studies were available. The Working Group urged NAMMCO to obtain reports from AMAP and other studies dealing with ringed seals and pollutants in the Arctic.

8. Recommendations

i) In the light of the magnitude of present catches in West Greenland and Canada and the uncertainty about their sustainability, it is strongly recommended that systems be initiated, maintained or improved for collecting detailed, complete and compatible catch statistics and information on effort from all areas. In addition to reports of landed catches of ringed seals, effort should be made to correct these figures for losses according to the different types of harvesting situations. Where appropriate, compilations of catch and loss should be further corrected for under-reporting.

ii) A major unknown factor regarding ringed seal biology is the importance of pack ice breeding. Since the seals breeding in the pack ice of Baffin Bay, the Greenland Sea and the Barents and western Kara seas are thought to contribute substantially to ringed seal production in these three regions, it is recommended that further studies of stock identity, productivity and abundance of pack-ice ringed seals be conducted.

9. Adoption of report

The report was adopted at 14.00 on 8 February 1996.

List of Documents

SC/4/RS/1	List of participants
SC/4/RS/2	Agenda
SC/4/RS/3	R.R. Reeves, World Review of Distribution, Abundance and Biology of the Ringed Seal (*Phoca hispida*).
SC/4/RS/4	C. Lydersen, Status and biology of ringed seals from Svalbard.
SC/4/RS/5	E.W.Born. How many ringed seals are needed to sustain all the polar bears ?
SC/4/RS/6	J. Teilmann and F.O. Kapel. Exploitation and status of the ringed seals (*Phoca hispida*) in Greenland.
SC/4/RS/7	M. Kingsley. Ringed seals in Canada.
SC/4/RS/8	A. Boltunov and S. Belikov. The ringed seal (*Phoca hispida*) in the West of the Russian Arctic.

References

Dietz, R., Heide-Jørgensen, M.P. & Born, E.W. 1985. Havpattedyr i Oestgrønland: en litteraturundersøgelse. Report to Råstofforvaltningen for Grønland and Grønlands Fiskeri- og Miljøundersøgelser by Danbiu ApS, Copenhagen. 277 pp.

Dietz, R., Hansen, C.T., Have, P. & Heide-Jørgensen, M.P. 1989. Clue to seal epizootic? *Nature* 338: 627.

Durner, G.M. and S.C. Amstrup 1995. Movements of a polar bear from Northern Aalska to Northern Greenland. Arctic 48 (4): 338-341.

Fedoseev, G.A. 1975. Ecotypes of the ringed seal (*Pusa hispida* Schreber, 1777) and their reproductive capabilities. *Rapp. P.-v. Reún. Cons. int. Explor. Mer* 169:156-160.

Finley, K.J., Miller, G.W., Davis, R.A. & Koski, W.R. 1983. A distinctive large breeding population of ringed seals (*Phoca hispida*) inhabiting the Baffin Bay pack ice. *Arctic* 36:162-173.

Harwood, L.A. & Stirling, I. 1992. Distribution of ringed seals in the southeastern Beaufort Sea during late summer. *Can. J. Zool.* 70:891-900.

Heide-Jørgensen, M.P., Stewart, B.S. & Leatherwood, S. 1992. Satellite tracking of ringed seals *Phoca hispida* off northwest Greenland. *Ecography* 15:56-61.

Kingsley, M.C.S. 1990. Status of the ringed seal, *Phoca hispida*, in Canada. *Can. Field-Nat.* 104:138-145.

Kingsley, M.C.S. and Byers, T.W. 1990. Status of the ringed seals in Thesiger Bay, 1987-1989. Report prepared for Fisheries Joint Management Committee, by Department of Fisheries and Oceans, Mont-Joli, Quebec, Canada.

Kingsley, M.C.S., Stirling, I. & Calvert, W. 1985. The distribution and abundance of seals in the Canadian high Arctic, 1980-1982. *Can. J. Fish. Aquat. Sci.* 42:1189-1210.

Lentfer, J.W. 1972. Alaska polar bear research and management. *In* Proc. of the 3rd Working Meeting of the Polar Bear Specialist Group, Survival Service Commission of IUCN. Publ. by New York Zoological Society and Conservation Foundation, Suppl. 35. [cited from Smith and Stirling 1975]

Lønø, O. 1970. The polar bear (*Ursus maritimus* Phipps) in the Svalbard area. *Norsk Polarinst. Skr.* 149:1-103.

Lowry, L.F. & Fay, F.H. 1984. Seal eating by walruses in the Bering and Chukchi seas. *Polar Biology* 3:11-18.

McLaren, I.A. 1958a. The biology of the ringed seal (*Phoca hispida* Schreber) in the eastern Canadian Arctic. *Fish. Res. Bd Canada Bull.* 118:1-97.

McLaren, I.A. 1958b. The economics of seals in the eastern Canadian Arctic. *Fish. Res. Bd Can.*

Arctic Circ. 1:1-94.

Miller, G.W., Davis, R.A. & Finley, K.J. 1982. Ringed seals in the Baffin Bay region: habitat use, population dynamics and harvest levels. Report for Arctic Pilot Project, LGL Ltd, Toronto. 94 pp.

Popov, L. 1982. Status of the main ice-living seals inhabiting inland waters and coastal marine areas of the USSR. Pages 361-381 *in* J.G. Clark (ed.), *Mammals in the seas. Volume 4. Small cetaceans. Seals. Sirenians and otters. Selected papers of the Scientific Consultation on the conservation and management of marine mammals and their environment. Bergen, 1976.* FAO Advisory Committee on Marine Resoures Research, Working Party on Marine Mammals, Rome. FAO Fish. Ser., (5) Vol. 4, 531 pp.

Rink, H. 1852-57. Grønland geografisk og statistisk beskrevet, I & II. A.F. Høst, København. 402 and 172 pp.

Smith, T.G. 1976. Predation of ringed seal pups (*Phoca hispida*) by the arctic fox (*Alopex lagopus*). *Can. J. Zool.* 54:1610-1616.

Smith, T.G. 1987. The ringed seal, *Phoca hispida*, of the Canadian western Arctic. *Can. Bull. Fish. Aquat. Sci.* 216:1-81.

Smith, T.G. & Hammill, M.O. 1981. Ecology of the ringed seal, *Phoca hispida*, in its fast ice breeding habitat. *Can. J. Zool.* 59:966-981.

Smith, T.G. & Lydersen, C. 1991. Availability of suitable land-fast ice and predation as factors limiting ringed seal populations, *Phoca hispida*, in Svalbard. *Polar Res.* 10:585-594.

Smith, T.G. & Stirling, I. 1975. The breeding habitat of the ringed seal (*Phoca hispida*). The birth lair and associated structures. *Can. J. Zool.* 53:1297-1305.

Stewart, R.E.A., Richard, P., Kingsley, M.C.S. and Houston, J.J. 1986. Seals and sealing in Canada's northern and arctic regions. Can. Tech. Rep. Fish. Aquat. Sci.1463:1-31.

Stirling, I. & Øritsland, N. 1995. Relationships between estimates of ringed seal (*Phoca hispida*) and polar bear (*Ursus maritimus*) populations in the Canadian Arctic. *Can. J. Fish. Aquat. Sci.* 52: (in press).

Vibe, C. 1950. The marine mammals and the marine fauna in the Thule district (northwest Greenland) witih observations on ice conditions in 1939-41. *Meddr Grønland* 150(6):1-115.

Ødegaard, Ø.A. & Krogsrud, J. 1981. Rabies in Svalbard: infection diagnosed in arctic fox, reindeer and seal. *Vet. Record* 109:141-142.

Figure 1. Delimitation of areas of ringed seal distribution as used in assessing abundance and exploitation - Areas 1, 2 and 3.

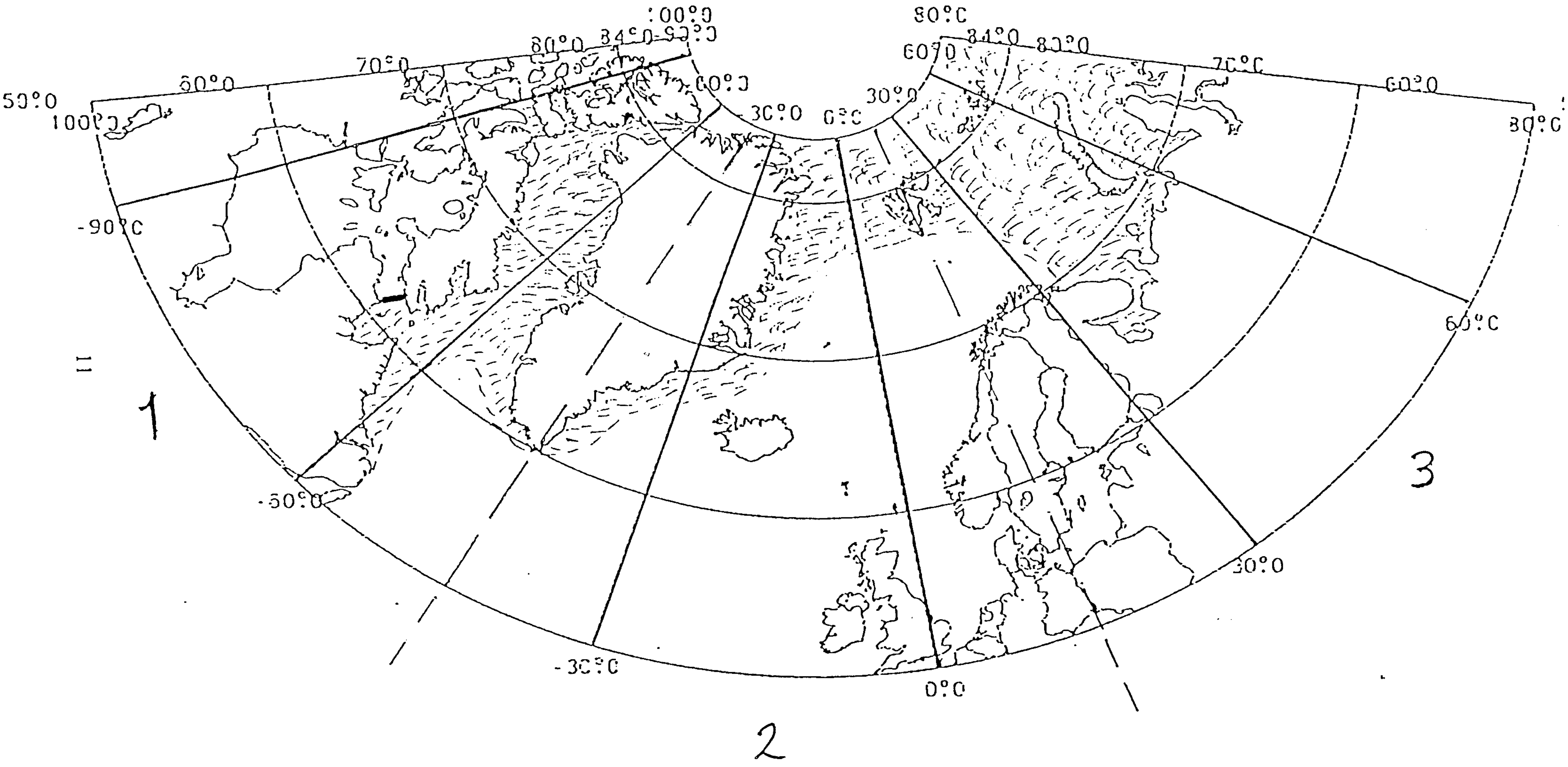


Figure 2. Estimation of polar bear predation on ringed seals

Estimation of ringed seals in Area 1 (Figure 1) from take by predators

I Polar bear energetics. a) Assume that the average polar bear needs the energy equivalent of 40 ringed seals per year;
b) assume that ringed seals are 75 to 90% of intake; i.e. 30 to 36 seals per year

c) Polar bear populations	Baffin Bay	Davis Strait	Kane Basin	Lancaster Sound	Total
	2200	1400	200	1700/2=850	4650

d) From a), b), and c), polar bear kill is 140 to 170 thousand ringed seals per year

II Ringed seal population model Extreme life history statistics for stationary populations, maximum age 30

Age	0	1	2	3	4	5	6	7	8+
Birth rate (F/F, %)	0	0	0	0	20	30	40	42	45
e) high juvenile survival (%)	70	75	80	85			86.4		
f) low juvenile survival (%)	40	55	70	85			96.7		

For e), production is 24% of after-pupping population, for f) it is 19%. Standing population of ringed seals to supply polar bear predation range within (140 to 170 thousand)/(0.19 to 0.24) = (580 to 890 thousand)

III Other predators: g) Assume other predators take 20% of polar bear take. Standing population becomes (580 to 890)x1.2 = (700 to 1070) thousand

IV Human hunters: h) Assume hunters take 100 thousand per year. Standing population to support this is (420 to 530 thousand)

V Total standing population after pupping is then: (1120 to 1600) thousand i.e. 1.1 to 1.6 million

Table 1. Ringed seal numbers in Baffin Bay and associated waters estimated from survey data

Region name	Fjord fast ice			Shelf fast ice			Stable pack ice			Total pop.
	Area	Density	Pop.	Area	Density	Pop.	Area	Density	Pop.	
Jones Sound			0	35.7	0.33	11.9			0	11.9
Kane Basin				18.5	0.33	6.16				6.16
East Lancaster Sound	1.4	1.7	2.38			0			0	2.38
Eclipse Sound & assoc. waters	8	1.7	13.6			0			0	13.6
West Greenland	40.6	1.7	69.02	10	1.3	13			0	82
West Baffin Bay	16.1	1.7	27.37	20	1.3	26	301	1.3	391.3	445
South Baffin Island	25.2	1.7	42.84			0			0	42.8
Ungava Bay	6.4	1.7	10.88			0	25.1	1.3	32.63	43.5
				Total surveyable population						647
				Survey correction factor						2.0
				Estimated total population						1294.0

Notes:

- Areas are in thousands of sq. km; densities are surveyable seals per sq. km; estimated populations are in thousands.
- Size of areas are taken from Miller et al.(1982); Finley et al. (1983); McLaren (1958b); Stirling and Øritsland (1995); and in the case of Ungava Bay pack ice and Kane Basin shelf fast ice are eye balled from small scale maps.
- The estimates of densities are taken from, or informed by, Kingsley et al. (1985) and from Finley et al. (1983); survey correction factor are from review by Stirling and Øritland (1995).

Table 2. Average catch 1980-94 (some years missing) according to the catch statistics distributed on hunting methods (SC/4/RS/6) and multiplied by average loss rates from Miller et al. (1982).

Region name	Average annual catch 1980-94	Shot in open water incl. 30.6% loss	Shot at ice edge incl. 31.7% loss	Shot on fast ice incl. 12.2 % loss	Netted incl. 0% loss	Total incl. loss
Northwest Greenland	31.639	7.851 (19% of the catch)	4.584 (11% of the catch)	6.745 (19% of the catch)	16.136 (51% of the catch)	35.316
North Greenland	13.485	3.346 (19%)	1.954 (11%)	2.875 (19%)	6.877 (51%)	15.052
Central West Greenland	4.895	1.215 (19%)	709 (11%)	1.044 (19%)	2.496 (51%)	5.464
Southwest Greenland	3.420	4.467 (100%)	0	0	0	4.467
South Greenland	2.306	3.012 (100%)	0	0	0	3.012
All West Greenland	55.745	19.891	7.247	10.664	25.509	63.311
Southeast Greenland	8.935	2.217 (19%)	1.294 (11%)	1.905 (19%)	4.557 (51%)	9.973
Northeast Greenland	3.204	795 (19%)	464 (11%)	683 (19%)	1.634 (51%)	3.576

Appendix 1

List of Participants

Stanislav Belikov
All-Russian Research Institute
for Nature Protection
Znamemskow-Sadki, Moscow 113 638
Russian Federation
Tel.: +7 095 4230133/311
Fax: +7 095 3232112
Email: arctos@glas.apc.org

Andrei Boltunov
All-Russian Research Institute
for Nature Protection
Znamemskoe-Sadki, Moscow 113 638
Russian Federation
Tel.: +7 095 4230133/311
Fax: +7 095 3232112
Email: arctos@glas.apc.org

Geneviève Desportes
Stejlestræde 9, Bregnør
DK-5300 Kerteminde, Denmark
Tel.: +45 65 32 17 67
Fax: +45 65 32 17 76
Email: gene@dou.dk

Mads Peter Heide-Jørgensen
Greenland Nature Research Inst.
Tagensvej 135, 1
DK-2200 Copenhagen N, Denmark
Tel.: +45 31 85 44 44
Fax: +45 35 82 18 50
Email: grfimphj@inet.uni-c.dk

Michael C.S. Kingsley
Maurice Lamontagne Institute
Fisheries and Oceans
P.O.Box 1000
Mont-Joli (Quebec)
G5H 3Z4 Canada
Tel.: +1 418 775 0500
Fax: +1 418 775 0542
Email: m_kingsley@am.qc.dfo.ca

Christian Lydersen
Norwegian Polar Institute
Boks 399, 9001 Tromsø
Norway
Tel.: 776 06700
Fax: 776 06701
Email: christian.lydersen@tromso.npolar.no

Randall R. Reeves
Okapi Wildlife Associates
27 Chandler Lane
Hudson, Quebec
J0P 1H0 Canada
Tel.: +1 514 458 73 83
Fax: +1 514 458 73 83
Email: rrreeves@accent.net

Aqqalu Rosing-Asvid
Greenland Nature Research Inst.
P.O.Box 570
DK-3900 Nuuk, Greenland
Tel.: +299 2 10 95
Fax: +299 2 59 57

Jonas Teilmann
Danbiu ApS
Tornagervej 2
2920 Charlottenlund
Denmark
Tel.: +45 40 53 36 97
Fax: +45 39 63 36 97
Email: danbiu@dk-online.dk

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

Report of the Scientific Committee *ad hoc* Working Group on Grey Seals *Halichoerus grypus*

Tórshavn 5-8 February 1996

1-3. Opening procedures

The *ad hoc* Working Group on Grey Seals met at the Nordic House in Tórshavn, Faroe Islands, 5-8 February 1996. The Chairman, Arne Bjørge, welcomed participants (listed in Appendix 1).

The Working Group had as its terms of reference the Council's request for advice on grey seals (*Halichoerus grypus*) which was to:

> "... review and assess abundance and stock levels of grey seals (*Halichoerus grypus*) in the North Atlantic, with an emphasis on their role in the marine ecosystem in general, and their significance as a source of nematodal infestations in fish in particular."

The Working Group adopted the agenda and decided to review the available working papers area by area (see List of documents. p. 16). For the general discussion, conclusions and recommendations, the Working Group decided to discuss all areas by topic.

Invited experts D.Thompson (UK) and M. Hammill (Canada) assisted the Chairman as rapporteurs.

4. Review of grey seal stocks

4.1 Stock Identity and Breeding Distribution

The grey seal (*Halichoerus grypus*) is a medium sized phocid found throughout the temperate waters of the North Atlantic. Three distinct populations are recognized: the western North Atlantic; the eastern North Atlantic; and the Baltic Sea grey seals. An examination of mitochondrial DNA variation in samples from Canada, Norway and the Baltic Sea found no shared haplotypes between the eastern and western Atlantic (Boskovic *et al.* submitted). According to this study, the distances between these two populations suggest that they diverged 1.0-1.2 million years ago. Nucleotide divergence between Baltic Sea and Norwegian grey seals, estimated to be around 0.7%, suggests that separation of Baltic and Northeast Atlantic grey seals took place around 350 thousand years ago based on standard divergence measures (Boskovic *et al.* submitted). The Working Group commented that if the separation of Northeast Atlantic and Baltic grey seals was established by the formation of the semi-enclosed Baltic Sea, the separation may be a more recent phenomenon due to the postglacial history of the Baltic Sea basin.

In the Northwest Atlantic two major groups of grey seals are recognized, based on the location of their whelping patches. The largest group breeds on Sable Island, a 40 km long sand bar located approximately 150 km to the east of Nova Scotia. The second group, known as the non-Sable Island grey seals, is made up of animals that breed on the small islands along the eastern shore of Nova Scotia and animals that whelp on the drifting pack ice in the Gulf of St Lawrence (Mansfield and Beck 1977). Recently a new breeding site was established at the Cape Cod Peninsula in USA. Although animals from both groups show strong philopatry to their whelping sites, considerable overlap occurs between the two groups in their distribution outside of the breeding season (Stobo *et al.* 1990; Lavigueur and Hammill 1993). An analysis of the mitochondrial DNA indicates that the two groups likely form a common stock (Boskovic *et al.* submitted).

The Northeast Atlantic grey seals are distributed from Iceland, Faroe Islands, British Isles and along the northwest coasts of mainland Europe. In Iceland the distribution is divided into two main areas (SC/4/GS/5). The majority of the population breed on the west and northwest coast, fewer at the southeast coast. Recently, grey seals established a new breeding colony in northeast Iceland. Historically, the distribution of the Icelandic grey seals has been changing. During the last 50 years it has dispersed from the west coast to the northwest and north coasts and now to the northeast coast. A few grey seals tagged in the UK have been found in Icelandic waters (E. Hauksson, pers. comm.). Thus, there is some evidence of mixing of Icelandic grey seals with other grey seal stocks in the North Atlantic, but the degree of mixing is unknown.

In the Faroe Islands, grey seals are frequently seen, and may be counted in hundreds at haul out sites, in particular at Mykineshólmur and Sumbiarbjørgini (D. Bloch, pers. comm.). No information is available on the distribution of grey seals in Faroe Islands. One grey seal tagged as a pup at North Rona, UK, in 1993 was shot in the Faroe Islands in the summer of 1994. Recently, grey seals tagged with satellite linked transmitters have migrated to the Faroe Islands. Historical and anecdotal information indicate that grey seals breed in caves on the Faroe Islands (SC/4/GS/6).

In the UK grey seal breeding colonies are found in Shetland, Orkney, North Rona, Outer and Inner Hebrides, on the north and northeast coasts of the Scottish mainland and on Isle of May, Farne Islands and Donna Nook on the North Sea coast. Smaller colonies are located in Wales and at the Scilly Islands in southwest Britain (SC/4/GS/8).

Grey seal breeding sites are located along the mainland coast of Europe from the Kola Peninsula, northern Russia, along the Norwegian coast, the German and Dutch Wadden Sea to France. The largest breeding groups are reported from Kola, Russia, and Froan in Central Norway (Anon. 1996).

In the Baltic Sea, grey seals normally breed on ice during late winter. There are large year to year differences in ice conditions and coverage, and the location of breeding varies between years. Due to mild winters, in Estonia the pups have been born on shore in recent years. Grey seals are still absent from most of their former range in the southern Baltic Sea (Anon. 1996).

In the Northeast Atlantic most grey seals breed in autumn from September to December, and the breeding season of Northeast Atlantic grey seals is therefore quite distinct from the late winter breeding of Baltic grey seals.

4.2 Distribution and movements outside breeding season

Knowledge on the distribution and movements of grey seals is available from anecdotal information, sightings, recovery of tags from bycaught or shot animals, or animals found dead on shore, and more recently from information provided by telemetry and pelage recognition programmes.

4.2.1 Distribution patterns

In the Northwest Atlantic, grey seals are found as far north as Cape Chidley in northern Labrador, throughout the Gulf of St Lawrence and along the Atlantic coast as far south as Virginia in the United States (Katona et al . 1993).

Sable Island animals appear to have a postbreeding pelagic phase (January-April) during which time they disperse from the island. This is followed by a spring moulting phase (May-June), then by a summer dispersal away from the island (July-September). At this time animals disperse towards the Nova Scotia, Maine and Newfoundland coasts and into the Gulf of St Lawrence. This is followed by a return to Sable Island during the fall and early winter (October-December) (Stobo *et al.* 1990).

This general movement pattern is also true for non Sable Island grey seals. The largest concentration of non-Sable Island grey seals is found in the Gulf of St Lawrence, where whelping occurs on the drifting pack ice in the southern Gulf during January-February. Tag returns and satellite telemetry indicate that after breeding adult grey seals move out of the Gulf onto the Scotian shelf (Lavigueur and Hammill 1993; Goulet, Barrette and Hammill unpublished data; Hammill, Lydersen and Kovacs unpublished data), where they remain offshore until the spring moult. The pups tend to remain with the pack ice as it drifts around the west side of the Cape Breton Coast into the Atlantic. However, in some years ice drift is slow, or there is little ice available which breaks up early in the season. When this occurs, many animals move ashore, where mortality may be high along the north coast of Nova Scotia and the west coast of Cape Breton Island. During May-June, both adults and juveniles move ashore to moult. Although some animals moult throughout the Gulf, most appear to move into the northern Gulf, around Anticosti Island and along the north shore (Clay and Nielsen 1985). After the moult, animals disperse, with many animals moving into the St Lawrence estuary (Lavigueur and Hammill 1993). During the fall, grey seals in the Gulf return to the southern Gulf for the breeding season, but this movement occurs slowly and late in the year (Goulet, Barrette and Hammill unpubl.data).

Between 1988 and 1993 SMRU (Sea Mammal Research Unit, UK) carried out a series of helicopter-based thermal image surveys around Scotland, and annual surveys of the Wash in south-east England during the common seal moult in August. The numbers of grey seals seen were also recorded. All sections of the Scottish coast were surveyed at least once over the six year period. Grey seals were found in groups throughout the Western Isles, along the west and north coasts of Scotland, throughout the Orkney and Shetland Isles and at various points down the east coast as far as the Wash. Concentrations of grey seals in summer were closely associated with breeding sites, with additional large haul outs in the estuaries of the Wash, the River Tay and the inner Moray Firth (SC/4/GS/8). There do not appear to be large scale shifts in population distribution as seen in Canada.

Recoveries of grey seals tagged in the UK suggest that there is a general dispersal of pups away from their natal sites, with recoveries from the entire North Sea basin as far as 67° on the coast of Norway. Migration rates between areas indicated that most 0+ age class seals remain within the sea area closest to their natal site, but that extensive movements occur between adjacent areas, with consequent mixing of pups from different breeding sites (SC/4/GS/8).

Swimming tracks of adult seals obtained from satellite and real time acoustic tracking showed large scale movements of up to 2,100 km and demonstrated frequent interchange between major haul-out areas. However, most seals spent most of their time on short (mean 2.7 days) and local (mean 47 km from haul-out site) foraging trips. For example, Farne Islands' seals spent 78% of their time within 50km of the islands. Foraging 'hotspots' could be identified. These were visited repeatedly by several seals and seemed to be associated with particular seabed sediment types (SC/4/GS/8).

4.2.2 Tagging and Telemetry Programmes

Conventional flipper tagging programmes have been conducted on grey seals in Canada since the 1970s. On Sable Island all pups were tagged between 1977 and 1990 (Stobo *et al.* 1990). For the non-Sable Island component of the population, tagging has been more sporadic. Approximately 2000 pups were tagged in each of 1984 ,85, 86, 89, 90, 94 and 96 on the pack ice in the Gulf of St. Lawrence. Smaller numbers (<1000) have been tagged on small islands along the eastern shore of Nova Scotia between 1984 and 1996. Tag recoveries have been used to estimate pup production of the non-Sable Island component (Hammill *et al.* 1990; Lavigne and Hammill 1993) and to examine the seasonal distribution of grey seals (Stobo *et al.* 1990; Lavigne and Hammill 1993).

In Britain flipper tags have been used extensively on grey seals since the 1960s. Early results from studies on the east coast showed a wide dispersal of pups. The last major tagging effort was in 1980 in the Hebrides, Orkney and Farne Islands. Most recoveries were from the 0+ age class. Recovery patterns were used to derive recapture effort and migration rate estimates between sea areas centered on the major breeding areas.

A flipper tagging programme began in central Norway in 1977 and more recently in Finnmark and at the Kola Peninsula.

In the UK VHF radio transmitters have been used to study movements of grey seals between the Farne Islands and Isle of May between November 1988 and December 1990. Automatic receiving stations (Nicholas *et al.* 1992) were placed at five sites along the coast. Movements between haul-out sites and activity patterns of 19 grey seals were recorded. In addition, the movements, dive behaviour and physiology of 11 grey seals were monitored using VHF and acoustic-telemetry. Seals were tracked from small boats and were recorded making extensive movements between haul-out areas and making foraging trips up to 80km offshore.

In the UK, satellite transmitters interfaced with depth and swim speed data loggers, have been deployed on 23 adult grey seals in the North Sea and approximately 15 in the Hebrides. In 1995 new miniaturized transmitters were deployed on weaned grey seal pups in the Outer Hebrides. Further deployments are planned for 1996. The same devices have been deployed on 5 grey seals in central Norway (Bjørge 1995) and on eight grey seals in the Baltic Sea (Sjøberg *et al.* 1993; SC/4/GS/8).

A total of 13 satellite tags have been deployed on grey seals in the Gulf of St. Lawrence. During October 1995 four satellite tags were deployed on grey seals on Sable Island. There are plans to deploy eight more on animals at Sable Island and five in the southern Gulf of St. Lawrence during the summer of 1996 (M. Hammill, pers. comm.).

4.2.3 Mark Recapture Techniques

Local population estimates, rates of movement between haul-outs and survival rates can be estimated using mark recapture techniques. Historically, plastic or metal tags were used to mark seals. These provide limited information due to tag loss, low rates of tag recovery and the fact that recoveries are often from dead animals.

Automated photo-identification techniques have recently been developed which use natural marks on seal pelage to identify individuals.Photographs of the side of the head are digitised and a standard sample of the pattern is extracted. Specially developed image processing software compensates for view point and seal posture. Images of the same seal produce a high similarity index when compared by a computer program. Pairs of photographs with high similarity measures are then compared by eye to confirm matches. Once entered into the database, each image is compared with all other entries to develop a capture history for each seal (Hiby 1995; SC/4/GS/8).

In a three year study in the North Sea, over 10,000 images were obtained giving 4,050 identifications, of which 2,400 were classed as well as marked. The study provided local summer population estimates and migration rates between haul-out areas. The catalogue is being maintained and expanded and is producing estimates of survival rates and updated population estimates. Comparisons between summer haul-out and breeding season catalogues will yield estimates of reproductive rates.

4.3 Population size and status

Grey seals were at one time very abundant and widely distributed along the Canadian east coast and in the Gulf of St Lawrence, where they were first hunted by Amerindians. Extensive hunting by Europeans, particularly after the disappearance of the walrus in the Gulf and on Sable Island, resulted in the depletion of the grey seal population by the mid-1800s (Lavigueur and Hammill 1993). By the early 1900s grey seals were still considered to be widely distributed, but there was no particular hunt for them owing to their small numbers. During the 1950s the grey seal in eastern Canada was considered to be uncommon or rare.

Grey seal pup production on Sable Island has been determined by complete enumeration between 1977 and 1990. Counts on Sable Island indicate that pup production has increased from 2,181 pups in 1977 to 9,712 in 1989 at an exponential rate of increase of 12.6% per year (Stobo and Zwanenburg 1990). Non Sable Island pup production estimates have been determined from mark-recapture experiments conducted between 1984 and 1990, where the pups were marked on the whelping patch and later shot during scientific collection programmes or by recapturing the animals live on Sable Island 3-10 months later. Using the best estimates, pup production increased from between 5,200 and 6,700 animals during the mid 1980s to between 8,300 and 10,700 during 1989-90 at an annual rate of increase of 8.8% (Hammill et al submitted). It is evident that the Sable Island and non Sable Island components of the population have undergone very different trajectories since the 1970s. During the 1970s, roughly 69% of the population was of non-Sable Island origin comprised mostly of animals in the Gulf of St Lawrence. However, by 1993 less than 43% of the total population of approximately 143,000 animals was of Gulf origin. Differences in the trajectories of the two groups likely result from the effects of the government sponsored cull of non Sable Island animals in the whelping areas, as well as higher probable mortality rates for pups born on the unstable pack ice in the Gulf of St Lawrence (Hammill *et al.* 1995).

Grey seals were first counted in Iceland in 1982. In the period 1982 to 1990 the population seems to have been stable or slightly increasing, but since 1992 and after that time the population appears to have been declining. The abundance of the grey seal around Iceland is now about 8,000 animals. In 1982 the population was estimated as 12,500 (9,550-14,400) animals (SC/4/GS/5).

Historical (Landt 1800) and anecdotal information indicate that grey seals breed in caves on the Faroe Islands. The population size was unknown, but supported a harvest (Johannessen 1967) and a bounty system between 1963 and 1967. A total of 970 seals was reported killed during this system (Reinert 1982). There is at present no estimate available for pup production in the Faroe Islands.

Approximately 40% of the world population of the grey seal breeds on 37 widely dispersed sites around the British Isles. The total number of births at all the major breeding sites in northern Britain has been monitored by aerial photographic surveys since the 1960s (SMRU). Pup productions at other sites at South Ronaldsay in Orkney, at the Farne Islands and in the Humber Estuary have also been estimated annually, from ground counts conducted by staff from Scottish Natural Heritage, the National Trust and Lincolnshire Trust for Nature conservation. Pup production estimates for Shetland and Wales are based on occasional surveys by SMRU and Dyfed wildlife trust (SC/4/GS/8).

Details of the aerial survey and photo-analysis techniques have been described fully by Hiby *et al.* (1988). The essential features are: a minimum of four flights are conducted over each site each year to trace the rise and fall in pup numbers ashore; the photographs provide complete coverage of the breeding site; the quality of the images is sufficient to allow pups to be distinguished from similar shaped and sized objects such as sheep and rocks, and allows pups to be classified into one of two developmental stages. Since 1985 colour transparency film has been used, facilitated by the development of an image motion compensation system (Hiby *et al.* 1987). This system provides a spatial resolution of about 5 cm on the ground and allows a proportion of moulted pups to be distinguished from whitecoats.

Since 1991 each site has been photographed at least four times at 10-day intervals. However, the timing and number of flights in previous years has been more variable.

Because the length of time pups remain ashore is short relative to the spread of birth dates, there is no time at which all the pups born are present. The number present at any time is a function of the birth rate up to that time and the rate of disappearance. Birth rate is estimated by fitting the count series to an underlying statistical model of the way in which the number of pups ashore varies through the season. (Rothery and McCann 1987, Hiby *et al.* 1988). An estimation procedure which produces maximum likelihood estimates of pup production for each site is fully described by Hiby *et al.* (submitted).

Population size is estimated by fitting a demographic model to the entire series of pup production estimates obtained since 1984. The size of the British grey seal population is defined as the number of seals born at a British breeding site which are alive at the start of the breeding season. The population is estimated as a whole because at present there is no objective basis for partitioning this geographically defined unit into biologically meaningful sub-units. The demographic model has been described fully by Hiby *et al.* (submitted).

The number of females in the population is estimated from the entire time series of pup production estimates. The size of the male component is then inferred from the female population estimate and information on relative survival values. The aim of this exercise is to derive an estimate of absolute abundance each year. These can be viewed as a time series, but being a long lived, annually breeding species the total population estimates provide a heavily damped indicator of changes in the population. The time series of pup production estimates provides a much more sensitive indicator of changes in numbers and distribution (SC/4/GS/8).

The demographic model is applied to all sites which are monitored annually, i.e. Inner and Outer Hebrides, North Rona, Orkney, the Isle of May and Farne Islands. Together these sites account for almost 90% of the pup production in Britain. The total population estimate for the annually monitored sites was 96,577 in 1994. By adding the most recent available estimates from all other breeding sites and multiplying by the total population:pup production ratio estimated from the model, an estimate of 108,500 for the total British grey seal population in 1994 is obtained. Of these, 99,300 seals are associated with breeding sites in Scotland and 9200 with sites in England and Wales.

Ninety-five percent confidence intervals on the pup production figures at each location are estimated to be within 14% of the point estimate. Ninety-five percent confidence intervals on the overall population estimate have been derived for the Farnes population. These were within 23% below and 38% above the point estimates. In Orkney pup production increased by approximately 4% p.a. between 1964 and 1982. Between 1970 and 1982 an average of 950 moulted pups were killed annually in a commercial hunt. Between 1984 and 1994 pup production increased by around 9-10% p.a.. In the Outer Hebrides pup production increased by approximately 6% p.a. between 1961 and 1982. The commercial hunt was less intensive and of shorter duration than in Orkney, with an average take of 515 p.a. between 1973 and 1979. Between 1984 and 1994 pup production has increased by around 5-6%, although in the last two years the increase has been only around 2% p.a.. In the Inner Hebrides pup production increased by 7.6% p.a. between 1984 and 1994. This area was not surveyed regularly before 1984. Coincident with the lower rate of increase in the Outer Hebrides, pup production in the Inner Hebrides in 1994 was lower than the 1992 value. The North-East English/South-East Scottish population was initially restricted to the Farne Islands. Between 1956 and 1971 pup production increased by 7% p.a., reaching a peak of 2,041. A series of control measures were carried out between 1971 and 1982 to reduce this population. Pup production was reduced to 1,238 p.a., but the measures had the effect of moving a proportion of the Farnes seals to the Isle of May, approximately 90km to the north. Since 1983 the combined population has continued to increase at 7% p.a (SC/4/GS/8).

Pup production has not increased uniformly at all colonies. For example, in the Outer Hebrides the Monach Isles have accounted for most of the increase since 1984. In Orkney, sites which produced a third of the total in 1987 have not increased at all while the total production increased at 10% p.a.. The patterns of variable growth rates at colonies within small geographical areas mean that it is not possible to monitor the pup production by counting only a few sites. Nor is it adequate to monitor just the current breeding sites, as newly colonised sites can increase rapidly in size. Calf of Eday and Copinsay in Orkney were not used for breeding before 1990, but by 1993 they contributed 7.5% of the total production. If a new colony is not included until it has grown to a significant size the estimated rate of increase will be over-estimated.

A discontinuity in the Orkney time series between 1982 and 1984 was probably due to improvements in photographic techniques. There is some indication of a similar effect in the Outer Hebrides although this could be the result of a decrease in pup production due to a cull of adult females in 1977. The immediate effect of the 1977 cull on pup production is obvious and is larger than would be expected purely as a result of the number of females killed (SC/4/GS/8).

Total pup production fell in 1988 and recovered by 1992. This is coincident with the phocine distemper epidemic which killed around 17,000 harbour seals (*Phoca vitulina*) in Europe. There was no evident increase in grey seal mortality at the time, but these figures suggest that there was an effect on fecundity or recruitment into the breeding population.

The reduced growth rate in the last two seasons in the Western Isles suggests that there may have been a decrease in fecundity. If fecundity has declined it would be misleading to extrapolate population size to future years using historical trends.

Figures of pup production are available for all known breeding sites along the mainland coast of northwest Europe, However, most figures are based on single counts. No confidence limits are therefore established for these figures. In most cases in Norway and Russia there are no time series available to evaluate trends in populations. The most recent counts, and therefore minimum figures for pup production are: 358 in Russia (Haug *et al.* 1994); 473 in Norway; 9 in Germany; 25 in the Dutch Wadden Sea; and 2 in France (Anon. 1995).

4. 4 Life history

In the Northwest Atlantic, whelping begins in late December and continues into late January on the small islands of Amet Island, and Deadman Island in the Gulf of St Lawrence, along the Nova Scotia Eastern Shore and on Sable Island (Mansfield and Beck 1977). Whelping also occurs on the drifting pack ice in the southern Gulf of St Lawrence, beginning in early to mid January and continues into early February (Hammill, unpublished data). Lactation lasts for approximately 15-16 days (Iverson *et al.* 1993; Baker *et al.* 1995). At birth the pups weigh 15-17 kg, gain 2.4-3.0 kg/d and are weaned at a mass of 51-56 kg (Bowen *et al.* 1992; Iverson *et al.* 1993; Baker *et al.* 1995). Males have been observed to be heavier at birth, grow faster and to be weaned at a greater mass (Baker *et al.* 1995), but this has not been observed in all studies (Bowen *et al.* 1992; Iverson *et al.* 1993).

In the Northwest Atlantic mean age for females giving birth for the first time is 5.5 y (sd=0.12). Reproductive rates for female grey seals using the presence or absence of a fetus are 0.18, 0.86 and 0.88 for females aged 4+, 5+ and > 6+ y. Among males a marked increase in testes weight is observed at age 3+ y. The mean age of physical sexual maturity is 5.6 y, and by age 7 virtually all males are sexually mature (Hammill and Gosselin, in press). However, animals do not appear to be able to hold tenure in the whelping patch until the age of 11-12 y (Godsell 1991).

Harwood and Prime (1978) reported from UK waters that 17% of grey seal females became pregnant at age four, 60% at age five, and the pregnancy rate was 90% for age six and older females. Grey seals examined by Harwood and Prime were sampled at the Farne Islands between 1972 and 1975. Boyd (1985) found that grey seal females in 1978-81 had their first pregnancy, on average, one year earlier. Boyd indicated that there may have been a decline in age at first pregnancy, alternatively that the difference between methods used by him and by Harwood and Prime (1978) have resulted in different estimates.

Little information was available on life history parameters from Iceland, the Faroe Islands and Norway.

4.5 Exploitation

Beginning in 1927, the Canadian government paid fishermen a bounty upon receipt of a harbour seal snout. In 1949, the system was changed to require presentation of the lower jaw before payment of the bounty. Since it is possible to identify the species by the lower jaw it became apparent that grey seals had been submitted in small numbers (Mansfield and Beck 1977). Between 1967 and 1984, the Department of Fisheries and Oceans conducted an annual cull at breeding colonies in the Gulf of St Lawrence and along the Nova Scotia eastern shore (Zwanenburg and Bowen 1990). From 1978 until 1990, a bounty was paid to licenced fishermen who submitted lower jaws from grey seals and information on date and location of capture. A total of 4,379 individuals were taken under the bounty program throughout its duration. Captures were initially quite high following introduction of the bounty program, but with the exception of a large number of returns in 1987 (753), declined steadily until 1990, when only 79 returns were received (Lavigueur and Hammill 1993).

In Iceland there is a directed hunt of grey seals. At earlier times grey seals were hunted, especially the pups for their skin, but also for their meat. Skins from grey seals have not been very valuable in Iceland in recent years, and hardly ever exported. Before 1982 records of number of seals killed were unreliable (SC/4/GS/5). In 1982 organizations of the fishing industry and fisheries in Iceland started promoting seal hunting, and since that time reliable information on catches is available (Anon. 1994).

Since 1982 shot grey seals have been utilized in food mixtures for fur-animals. The skin has been used in leather and garments. Some of the meat is also used for human consumption (SC/4/GS/5).

In UK waters a total catch of 16,501 and 4,527 grey seals were reported for the decades 1970-79 and 1980-89, respectively. Since 1990 a total of 45 has been reported taken (Anon. 1995). In Norway there is a hunting season from 1 December to 30 April in areas north of approximately 62°N. Hunting is known to occur (Haug *et al.* 1994), although no system is established to record effort or catch statistics in this hunt.

In the Faroe Islands fish-farmers are permitted to shoot seals near fish farms. According to Mikkelsen *et al.* (SC/4/GS/6) the number killed may be significant, and may have prevented the Faroese grey seal population from increasing over the last decade. Also in several other countries grey seals may be killed legally if they approach fish farms. Although numbers of seals shot in order to protect fish farms or standing fishing gear are believed to be significant in some areas, levels of such kills are virtually unknown. By-catches of grey seals in fishing gear are known to occur. Return of tags indicates that seals less than one year of age are particularly vulnerable to entrapment in fishing gear (Bjørge and McConnell 1986). A total by-catch of 300 grey seals in 1994 is reported from the Baltic Sea population (Anon. 1995). In general, levels of by-catches of grey seals, and of other marine mammals species, are poorly documented.

4. 6 Conclusions and Recommendations

Outside the breeding season there is extensive overlap in distribution of grey seals from different breeding colonies. There is evidence of inter-annual site fidelity of sexually mature grey seals (Wiig and Øien 1988; McConnell *et al.* 1992; Pomeroy *et al.* 1994; Twiss *et al.* 1994). However, the degree of exchange of animals and genetic flow between breeding groups within the three populations of grey seal is not well studied, but some mixing between groups has been reported (Harwood *et al.* 1976). The Working Group appreciated the recent information on stock identity made available by analyses of mt DNA. The Working Group encouraged further sampling for genetic analysis and noted that frozen blood or skin samples are relevant for such analyses.

The Working Group **recommended** that samples are taken when live capture seals and shot samples or bycatches are available and advised a sample size of 20-30 animals from each breeding unit. Further, the Working Group **recommended** exchange of samples between laboratories on both sides of the Atlantic.

The distribution in space and time of foraging activity is essential for further understanding of the impact of grey seal on marine resources and the marine ecosystem. Such information can be obtained by pelage recognition programmes (Hiby 1995) and satellite tracking of free ranging seals. Where there are by-catches of grey seals in fishing operation, conventional flipper tags may also contribute to this knowledge. The Working Group **recommended** the use of satellite linked tags for further studies of distribution of grey seals at sea. The costs of satellite tags often limits the number of seals monitored. The Working Group therefore encourages any development of new, less expensive tags for long range telemetry.

Most abundance estimates are obtained from pup counts. The Working Group underlined the need for full descriptions of the methods used to obtain these estimates, of the statistical properties of the estimates and of actual and potential bias in the estimates. The Working Group **recommended** when possible multiple surveys and establishment of confidence limits with the estimates of pup production. When multiple surveys within years are not possible, the Working Group **advised** that well defined and described surveys may be used to establish an index of trend in pup production. The Working Group recognized the potential for photo-identification techniques to provide population estimates when or where pup production estimates cannot be estimated.

Population models show that seal populations in general are more sensitive to changes in mortality than to changes in fecundity rates. Changes in adult mortality have the largest impact on populations. Hunting mortality may be established from catch statistics, but such statistics are not always available, e.g. catches in the hunting season in northern Norway. The Working Group **recommended** further studies to investigate pup mortality, juvenile mortality, adult mortality, fecundity, age at first reproduction and growth parameters.

The Working Group refers to the hunting season for grey seals in Norway and **recommended** that a system for recording catch statistics is established as soon as possible. The Working Group further **recommended** that all countries having fishing operations within the range of the grey seal establish a system for obtaining and reporting by-catches of grey seals (and other marine mammals). Observer schemes are regarded as the most reliable method to obtain by-catch information. Observer schemes, however, are expensive and difficult in practical terms in fisheries where a large number of small units are operating. The method for obtaining by-catch statistics should therefore be modified to match the respective fisheries. From a scientific point of view, it is important that methods used are well documented so that the statistical properties of by-catch estimates may be explored.

The grey seal hunt in Iceland is well documented. Since the fishing industry started their programme to augment the harvest in 1982, about half the pup production and an additional hunt of one year old and older seals are taken each year. Estimates of pup production and age samples of one year old and older seals are also available. This is an example where the annual hunt seems to have a significant and clearly detectable impact on the population size and trend. The Working Group **recommended** that the age distribution of this population is further studied if age samples become available, and that the effect of harvest on demography and population size is documented.

5. The role of the grey seal in the marine ecosystem

5.1 Food preference and consumption

5.1.1 Canadian waters

Over 40 different prey including many commercially important fish species have been identified in the diet of Northwest Atlantic grey seals (Benoit and Bowen 1990a). Like most pinnipeds, strong regional and seasonal changes in grey seal diet composition have been observed. In the northern Gulf of St Lawrence capelin (*Mallotus villosus*) lumpfish (*Cyclopterus lumpus*), herring (*Clupea harengus*), and cod (*Gadus morhua*) are the most important prey species accounting for over 60% of the diet by frequency of occurrence (Benoit and Bowen 1990b; Murie and Lavigne 1992; Proust 1996). Seasonal changes in diet are evident with capelin and lumpfish being important prey during the period May to July, with cod and herring becoming the dominant prey species during August and September (Benoit and Bowen 1990b; Proust 1996). In the southern Gulf of St Lawrence cod, herring and flatfish were the most important prey (Benoit and Bowen 1990a). In grey seals collected from the Atlantic side of Nova Scotia and Sable Island consumed cod, herring, hake (*Merluccius bilinearis*), sand lance (*Ammodytes dubius*) and flatfish (*Pleuronectiformes*) formed the most important prey (Bowen *et al.* 1993; Bowen and Harrison 1994). Near Sable Island sand lance, although an important component of the diet throughout the year, account for a greater percentage of the diet by weight during the winter than during summer. Cod and silver hake were consumed primarily during the late summer when these species move into the shallower water over the offshore banks surrounding Sable Island (Bowen and Harrison 1994). Some differences between nearshore diets and the offshore diets of animals from around Sable Island have also been noticed (Bowen and Harrison 1994). In grey seals collected from the Eastern Shore of Nova Scotia, herring and mackerel (*Scomber scombrus*) (Bowen *et al.* 1993) replaced sand lance and flatfishes as important foods.

Several studies have observed that grey seals feed primarily on fish <40 cm in length, which for most species represent size ranges too small for the commercial fishery (Benoit and Bowen 1990b; Murie and Lavigne 1992; Bowen *et al.* 1993; Bowen and Harrison 1994; Proust 1996). Some notable differences have been observed between studies or within studies between years. For example Bowen *et al.* (1994) observed that grey seals consumed larger herring during the fall on the Scotian shelf (mean length=34.5 cm) than did grey seals feeding on herring during summer in the northern Gulf (mean length=24.9)(Benoit and Bowen 1990b). More recently Proust (1996) observed that grey seals feeding on cod in a sample obtained in 1988 had a mean length of 32.1 cm, while cod consumed in a sample obtained in 1992 had a mean length of 39.6 cm. These differences in the length-frequency distributions of prey consumed may be related to the relative abundance of particular year classes in the population (Proust 1996).

The possibility of competition between marine mammals and fisheries often generates considerable controversy with fishers on one side of the debate and environmental groups on the other (Hammill *et al.* 1995). Historically, this competition has been of limited importance because many species of marine mammals were harvested for food or other commercial purposes. However, during the last 20 years, there has been a marked shift in public attitudes towards harvesting of marine mammals, resulting in a dramatic decline in the demand for their products. Consequently, harvests have declined, and many populations appear to be increasing. Also, since both fishers and marine mammals often "forage" in the same area, marine mammals are perceived as having a negative impact on commercial fisheries (Hammill *et al.* 1995).

In order to estimate total fish consumption, information is required on the size, structure and dynamics of the seal population, the geographical and temporal distribution of animals, individual energy requirements, and diet composition. Consumption of Atlantic cod by the Northwest Atlantic grey seal has recently been examined for the Scotian shelf and Gulf of St Lawrence (Mohn and Bowen 1994; Hammill *et al.* 1995). Depending on model assumptions (Hammill *et al.* 1995), particularly assumptions concerning the seasonal distribution of the grey seal population in Atlantic Canada, cod consumption has increased from less than 4,000 tons in the Gulf of St Lawrence and 1,500 tons on the Scotian Shelf in 1970 to nearly 40,000 tons in 1993, including 17,000 tons in the Gulf of St Lawrence and 17,000 tons on the Scotian Shelf and 4,000 tons in other areas throughout Atlantic Canada (Hammill and Mohn 1994; Hammill *et al.* 1995). Owing to low biomass estimates, the cod fishery in Atlantic Canada has been closed since 1992.

Thus in relative terms the consumption of 40,000 t of cod by grey seals is significant compared to current harvests by the industry. The impact of this consumption on the recovery of Northwest Atlantic cod stocks is difficult to assess, since >80% of this consumption would be prerecruits to the commercial fishery and it is likely that some compensatory mortality occurs which would reduce the magnitude of this impact. Recently, Mohn and Bowen (1994) have attempted to assess the impact of grey seal consumption of cod on the Scotian shelf, but these efforts have been hampered by the lack of information on natural mortality rates of juvenile cod.

5.1.2 Icelandic Waters

The most prominent (% occurrence) prey species found in the stomach of grey seals in Icelandic coastal waters are lumpsucker, the common spider crab (*Hyas sp*), catfish, cod, the hermit crabs (*Eupagurus sp.*) and bull-rout, but several other fish species were recorded. During the feeding season from January-September, grey seals feed mostly on cod, lumpsucker, sand eel and catfish. Sand eel is the dominant species at the south coast while lumpsucker, cod and catfish dominate in all other areas of Icelandic coastal waters (SC/4/GS/5).

In the breeding season, sand eel still dominates at the south coast, while bull-rout, spider crabs, sand eel and cod are important in northwest, and cod dominates in the northeast (SC/4/GS/5).

5.1.3 Faroese waters

Mikkelsen *et al.* (SC/4/GS/6) reported that diet composition varied between sampling sites in the Faroe Islands. At Svínoy (n=13) in the northeast cod dominated the diet and other gadid species were frequent. At Sandoy (n=14), wolffish (*Anarchicas lupus*) was the most frequent species, closely followed by lemon sole (*Microstomus kitt*). Off Mykines (n=13) at the western point of the Faroe Islands, sandeel dominated the diet.

5.1.4 UK waters

The Sea Mammal Research Unit has studied the diet of grey seals around the UK coast for over 10 years by analysis of hard remains in faecal sample found on haul-out sites. During the last three years studies have concentrated on the assessment of diet at the Farne Islands, in the North Sea, during the summer months. The following descriptions of the diet and food consumption patterns are extracted from SMR, cited in SC/4/GS/9.

Grey seal faeces were collected from haul-out sites in the Inner and Outer Hebrides, Orkney Islands, Fair Isle, Loch Erribol and Helmsdale on the northern Scottish mainland, Isle of May and Farne Islands and at Donna Nook on the English east coast. Stomach and large intestine samples were collected by stomach lavaging and rectal enema at the Farne Islands during summer 1992.

The methods of processing and analysis of the faecal samples and the subsequent estimation of the proportion of each species in the diet have been fully described in Prime and Hammond (1987; 1990). Hard parts were extracted by passing the samples through 0.4 mm sieves under running water. All fish otoliths and cephalopod beaks were identified to species (except sandeels (Ammodytidae) which were simply identified as such) using an extensive reference collection and identification guide (Härkönen 1986). Thickness, length and width of each otolith were measured to 0.01 mm. Thickness only was used for sandeels.

Species specific digestion coefficients obtained from a series of feeding trials (Prime & Hammond 1987) were used to estimate undigested otolith size. Fish weights were estimated using empirical fish weight to otolith dimension relationships (Prime & Hammond 1987). Digestion coefficients and fish length/weight to otolith thickness relationships for all species examined are given in Prime & Hammond (1990) and Hammond *et al.* 1994 (cited in SC/4/GS/9).

In Orkney and north-eastern Scotland sandeels were the most important item in the diet, accounting for almost half the fish consumed by weight except in the east of the region in February. The rest of the diet comprised mainly larger gadid species (particularly cod (*Gadus morhua*) and ling (*Molva molva*)) and flatfish (particularly plaice (*Pleuronectes platessa*)). Sandeels were more prevalent in February and in the summer than in November. No significant regional or seasonal differences were found in the number of cod, haddock (*Melanogrammus aeglefinus*) or saithe (*Pollachius virens*) consumed. Whiting (*Merlangius merlangus*) were important in November in the south of the region and ling were the dominant gadid in the north and west in February and in the west and east in November.

In the Inner and Outer Hebrides gadids predominated in the diet. They contributed approximately 40% or more of the diet by weight. The most abundant gadid species were ling, cod and whiting. The dominant gadid species varied by area and season. E.g. in the Monach Isles ling were important in January and June, cod were important in June and November, and whiting were important in August and November.

Flatfish were a major part of the diet, especially in the Outer Hebrides. Again the dominant species varied between areas and seasons. Sandeels were less important in the western isles than in any other region of the UK. Interestingly, pelagic schooling fish including mackerel (*Scomber scomberus*), herring (*Clupea harengus*) and horse mackerel (*Trachurus trachurus*) were more important than in other regions.

At the Isle of May the samples were restricted to the pupping season and February. Again cod and sandeels dominated the diet, accounting for over 70% of the prey consumed. Cod was the most important component of the diet, accounting for 35-64% of the November/December diet each year. There were large between year fluctuations in the importance of sandeels, from 0.6 to 40%.

At the Farne Islands the diet during the pupping season was also dominated by sandeels (mean=54.1%) and cod (29.9%). Unlike at the Isle of May there was little variation in the percentage of sandeels or cod between years. During the spring there was more variability, with sandeels (20%) and cod (34%) again being important, but whiting (23%) being the dominant species in 1983.

The summer diet at the Farne Islands has been assessed from gut contents of seals shot in 1981 and stomach and large intestine washout samples collected in 1992. Again sandeels and gadids were the predominant constituents of the diet, accounting for over 90% in both years. The large intestine samples in the two years were similar, 67-69% sandeels and 27-29% gadids.

In the south of the grey seal range in the North Sea, represented by samples from Donna Nook, the diet consisted mainly of sandeels (26.4%), gadids (particularly cod (17.6%)) and flatfish (particularly Dover sole (12.2%)).

The relative importance of each prey species varied through the year. Initially roundfish, especially cod and sandeels, predominated. During the spring flatfish were the dominant food items accounting for around 60% of the diet. During the summer and autumn sandeels dominated, with flatfish in early summer and roundfish in late summer-autumn. By December sandeels had disappeared and the diet was 70% flatfish.

These data show that a small number of species form the core of the diet of grey seals in British waters. In all areas sandeels and large gadids accounted for over 70% of the diet by weight, except at Donna Nook where they made up only 50%. At all the major grey seal concentrations a reduction in the sandeel percentage was compensated by an increase in the gadoid percentage. The dominant gadoid was cod except in the Hebrides where ling were important.

Hammond, Hall and Rothery (1995 - cited in SC/4/GS/9) carried out an assessment of the annual consumption of fish by the North Sea grey seal population and compared this to the commercial catch. Because the diet varies both geographically and seasonally it is appropriate to stratify estimates of consumption by area and season and to sum across seasons to estimate annual consumption for each area. For each area data on the percentage by weight of each prey species were combined with seasonal estimates of seal numbers, seal energy requirements and fish energy densities to estimate annual consumption of each major prey species.

Grey seals consume a wide range of prey sizes, including many small fish, so it is appropriate to consider consumption in relation to total stock biomass. A direct comparison shows that typically grey seals' consumption is around two orders of magnitude less than stock biomass for any species. In the worst case cod consumption upper 95% confidence limit is around 6% of the lowest cod stock biomass estimate in the last decade. Sandeels and cod are the two most important species by mass in the grey seal diet. The consumption over biomass (average biomass between 1983-92) was 36,130 tons/2,050,000 tons and 10,464 tons/428,000 tons for sandeel and cod, respectively.

Although annual removals of fish biomass by seals are small on a North Sea wide scale, there may be local areas where fish consumption by seals is more important. The concentration of seal foraging in small areas supports this suggestion (McConnell *et al.* 1992).

5.2 Recommendations

The Working Group underlined the significance of information on distribution of foraging activity in space and time when the role of marine mammals in the ecosystem is to be evaluated. In order to monitor the movements, the Working Group **recommended** further studies using satellite tags on grey seal. Where possible these should be combined with studies of diet and food availability. The Working Group further **recommended** that when diet studies are based entirely on either shot samples or fecal samples, attempts should be made to calibrate the method by comparing ingestion and excretion of identifiable prey in captive seals. The Working Group noted the limited data on population size, diet and foraging behaviour of grey seals in Norway and **recommended** that such studies be undertaken.

6. Grey seals as a source of nematodal infestation in fish

6.1 Review of parasitic nematodes transferred from seals to fish

Four species of anisakine nematodes with fish as intermediate hosts occur in the stomach or intestine of grey seals (e.g. Scott and Fisher 1958; Templeman 1990; SC/4/GS/5). The most abundant is *Pseudoterranova decipiens*, the cod worm, but *Anisakis simplex*, *Contracoecum osculatum*, *Phocascaris cystophora* are common in several areas. The three first species occur in the stomach cavity while *P. cystophorae* occurs in the pyloric caeca close to the junction to the stomach.

Recently, enzyme electrophoresis and other methods of molecular taxonomy have show that *A. simplex* is composed of two sibling species, *P. decipiens* of three and *C. osculatum* of three sibling species (Berland and Fagerholm 1994). The sibling species A of *P. decipiens* dominates in the Northwest Atlantic. In the Northeast Atlantic sibling species B dominates in grey seals while A dominates in harbour seals.

The larval stages of *P. decipiens* penetrate the intestine and infest the muscle of the fish. The easily visible, up to c. 50mm long worm strongly reduces the commercial value of fish fillets, is an important problem to fish industry in areas where infestation is high (e.g. Bjørge *et al.* 1981; Templeman 1990). The *P. decipiens* is therefore discussed in more detail below.

6.2 Population biology of the Pseudoterranova decipiens

The *Pseudoterranova decipiens* attain sexual maturity in the stomach of seals and in particular in grey seals (e.g. Templeman 1990; McClelland *et al.* 1990; Bjørge *et al.* 1981). The partly embryonated ova are passed with faeces into sea water. The embryonated ova have a slightly negative buoyancy and the freshly hatched, still ensheated small larvae adhere to the substrate by a caudal extremity. In the next step the small larvae are found in haemocoel of benthic copepods and in e.g. amphipods and isopods. Still small larvae then occur in body cavities and musculature of of benthophagus fish. Larger larvae occur in the body cavities and musculature of benthic piscivore fish. The final larval stage of the parasite then enters into the stomach of the final host i.e. piscivore mammals and the *P. decipiens* matures and completes the life cycle (Bjørge 1979; McClelland 1990; McClelland *et al.* 1990).

6.3 Abundance of Pseudoterranova decipiens in grey seals and other mammals

Although there are four species of pinnipeds found throughout Atlantic Canada, the grey seal is the most important as a vector for the nematode *P. decipiens*, known also as codworm or sealworm (Mansfield and Beck 1977). Sexually mature worms have been found in grey seals as young as 3-4 months of age. Worm burdens are linked to size with males carrying heavier burdens than females owing to their larger size (Stobo *et al.* 1990). Seasonal changes in sealworm burdens have been observed, with declines observed during the breeding season, probably as a result of animals fasting and a second decline observed in late summer. This decline may be linked to a change in diet as grey seals switch to prey with lower infection levels (Stobo *et al.* 1990).

In Iceland, the prevalence of *P. decipiens* in grey seals was 100% in all areas and seasons, but the mean abundance varied from 160 worms (n=15, se=57) at the south coast in October, to 3,972 worms (n=24, se=974) at the northwest coast in October. At the northwest coast the abundance of codworm in summer numbers some hundred worms per seal, and the increase in abundance in October may be linked to a change in diet. During the breeding season in October the grey seals feed on heavily infested sculpins (38% frequency of occurrence) (SC/4/GS/5).

6.4 Abundance and prevalence of Pseudoterranova decipiens in fish

Although codworm is considered to be mildly pathogenic if consumed in raw or poorly cooked fish, the major impact is considered to be a cosmetic one, with high infections rendering fish unappealing to consumers. The cost of removing larvae from cod fillets alone were estimated to be in excess of $29 million in Atlantic Canada in 1982 (Bowen 1990).

Surveys conducted during the 1950s indicated that sealworm was found in the fillets of groundfish throughout Atlantic Canada, but the heaviest infections were limited to cod from the southern Gulf of St Lawrence, and inshore areas of southwestern Newfoundland, Nova Scotia and the Bay of Fundy (McClelland *et al.* 1985). Surveys conducted during the mid 1980s indicated that sealworm levels had increased in many regions throughout the Gulf of St Lawrence and Nova Scotia, particularly in the Miramichi area of the Gulf of St Lawrence and the Sable Island area of the Scotian Shelf (McClelland *et al.* 1985). Further increases in worm burdens have been observed in the Gulf of St Lawrence between the 1983 samples from McClelland *et al.* (1985) and samples collected in 1990 (Boily and Marcogliese 1995). These increases are believed to be linked to increases in the grey seal population that has been observed since the 1970s. However, high geographical and temporal variability in sealworm levels may be linked not only to the distribution of definitive hosts such as seals, but also to other factors such as variability in water temperatures (Boily and Marcogliese 1995). Surveys completed to determine nematode abundance among grey seals have shown that mean burdens have increased from 158-700 nematodes per seal between 1948-1956 (Scott and Fisher 1958 in Marcogliese and Boily submitted) to >1000 in 1990 (Marcogliese and Boily submitted). However, a decline in sealworm abundance and an increase in the abundance of the nematode *Contracaecum osculatum* have been observed in samples collected in the Gulf between 1988 and 1992 and it has been suggested that the recent cooling in the cold intermediate layer of the Gulf of St Lawrence may have had a positive effect on the abundance of *C. osculatum* at the expense of sealworm (Marcogliese and Boily submitted).

No significant change has been observed in *P. decipiens* abundance in cod from coastal waters of Iceland between 1980 and 1990 (SC/4/GS/5). The highest abundance of *P. decipiens* was recorded in sculpins at the west coast (n=71, 95.2 worms per fish, range 9-448). In this sample there were an average of 34 worms per 100 g fish (SC/4/GS/5).

In Norway, however, considerable variations between areas and years were observed for *P. decipiens* burden in cod (Haug *et al.* 1991). The abundance ranged from 0 to 70 parasites per fish. Close to a major grey seal haul-out mean abundance of 21 worms per fish was recorded (n=43, sd=18.6).

6.5 Recommendations

The complex life cycle of sealworm will complicate any attempt to control infestation levels in fish. Seven major areas requiring further research have been identified (Marcogliese and McClelland 1994). Based on this list and further discussions in the Working Group, the Working Group **recommended** that the following topics be given priority:

1) Establish time series of data on seal diet and levels of sealworm infestation in fish populations in the same areas;

2) Determine whether worm size and/or worm fecundity in seals are dependent on parasite densities;

3) Determine the importance of small benthophagus fish in the life cycle of the parasite, with special emphasis on sculpins;

4) Determine the longevity of sealworm and host response in important seal prey species;

5) Determine distribution and abundance of the sealworm in the macro invertebrate hosts;

6) Investigate further the role of temperature on sealworm transmission and development;

7) Determine whether infection of sealworm in fish produces behavioural modifications which facilitate transmission to seals.

List of documents

SC/4/GS/3	A. Bjørge, Grey seals in Scandinavian and adjacent waters
SC/4/GS/5	E. Hauksson, Studies on the Icelandic grey seal; population status, food preference, interactions with fisheries and a source for nematode infection in fish
SC/4/GS/6	B. Mikkelsen, Summer diet of grey seals (*Halichoerus grypus*) in the Faroe Islands
SC/4/GS/7	M. Hammill, The Status of the Grey Seal in the Northwest Atlantic
SC/4/GS/8	D. Thompson. Size and status of the British grey seal population
SC/4/GS/9	D. Thompson. Diet of grey seals in British waters

References

Anon. 1994. State of the marine stocks in Icelandic waters 1993/94. *Fisheries Prospects 1994/95.* Marine Research Institute, Reykjavik.

Anon. 1996. Report of the ICES Study Group on seals and small cetaceans in European Seas. Cambridge, UK, 4-6 December 1995. ICES CM 1996/N:1. 20 pp + tables 33 pp.

Baker, S.R., Barrette, C. and Hammill, M.O. 1995. Mass transfer during lactation of an ice-breeding Pinniped, the grey seal (*Halichoerus grypus*), in Nova Scotia, *Canada. J. Zool.* 236: 531-542.

Benoit, D. and Bowen, W.D. 1990a. Seasonal and geographical variation in the diet of grey seals (*Halichoerus grypus*) in Eastern Canada. Pp 215-226 in W.D. Bowen (ed). Population biology of sealworm (*Pseudoterranova decipiens*) in relation to its intermediate and seal hosts. *Can. Bull. Fish.Aquat. Sci.* No 222. 306 pp.

Benoit, D. and Bowen, W.D. 1990b. Summer diet of grey seals (*Halichoerus grypus*) at Anticosti Island, Gulf of St Lawrence, Canada. Pp 227-242 in W.D. Bowen (ed). Population biology of sealworm (*Pseudoterranova decipiens*) in relation to its intermediate and seal hosts. *Can. Bull. Fish. Aquat. Sci.* No 222. 306 pp.

Berland, B. and Fagerholm, H.P. 1994. Thirthy years of anisakid research, and future trend. *Bull. Scand. Parasitol.* 4 (2): 40-46.

Bjørge, A.J. 1979. An isopod as intermediate host of cod-worm. *Fisk Dir. Skr. Ser. Hav Unders.* 16: 561-565.

Bjørge, A. 1995. Comparative habitat use and foraging behaviour of harbour seals and grey seals in western Norway. ICES C.M. 1995/ N:1. 13 pp.

Bjørge, A., Christensen, I. and Øritsland, T. 1981. Current problems and research related to interactions between marine mammals and fisheries in Norwegian coastal and adjacent waters. ICES C.M. 1981/N:18.

Bjørge, A, and McConnell, B. 1986. Recoveries in Norway of grey seals, *Halichoerus grypus*, tagged in Great Britain. *Fisken Hav.*, 1986(2): 1-8.

Boily, F. and Marcogliese, D.J. 1995. Geographical variations in abundance of larval anisakine nematodes in Atlantic cod (*Gadus morhua*) and American plaice (*Hippoglossoides platessoides*) from the Gulf of St Lawrence. *Can J. Fish. Aquat. Sci.* 52: 105-115.

Boskovic, R., Kovacs, K.M., Hammill, M.O., and White, B.N. (in manuscript). Geographic distribution of mitochondrial DNA haplotypes in grey seals (*Halichoerus grypus*). Submitted, *Can. J. Zool.*

Bowen, W.D. 1990. General intoduction. Pp vii-viii in W.D. Bowen (ed). Population biology of sealworm (*Pseudoterranova decipiens*) in relation to its intermediate and seal hosts. *Can. Bull. Fish. Aquat. Sci.* No 222. 306 pp.

Bowen, W.D., Lawson, J.W. and Beck, B. 1993. Seasonal and geographic variation in the species composition and size of prey consumed by grey seals (*Halichoerus grypus*) on the Scotian Shelf. *Can. J. Fish. Aquat. Sci.* 50: 1768-1778.

Bowen, W.D. and Harrison, G.D. 1994. Offshore diet of grey seal *Halichoerus grypus* near Sable Island, *Canada. Mar. Ecol. Prog. Ser.* 112: 1-11.

Bowen, W.D., Stobo, W.T. and Smith, S.J. 1992. Mass changes of grey seal *Halichoerus grypus* on Sable Island: Differential maternal investment reconsidered. *J. Zool.* 227: 607-622.

Boyd, I.L. 1985. Pregnancy and ovulation rates in grey seals (*Halichoerus grypus*) on the British coast. *J. Zool.* 205: 265-272.

Clay, D. and Nielsen, G. 1985. Grey seal (*Halichoerus grypus*) distribution during 1983/84 in the Gulf of St Lawrence as observed by arial survey. *Can. Ms. Rep. Fish. Aquat. Sci.* No 1836. 8pp.

Godsell, J. 1991. The relative influence of age and weight on the reproductive behaviour of male grey seals, *Halichoerus grypus*. *J. Zool.*224: 537-551.

Hammill, M.O. and Mohn, B.O. 1994. A model of grey seal predation on Atlantic cod on the Scotian Shelf and Gulf of St Lawrence. DFO Atl. Fish. Res. Doc 94/75. 25 pp.

Hammill, M.O., Ryg, M.S. and Mohn, B. 1995. Consumption of cod by the Northwest Atlantic grey seal in eastern Canada in A.S. Blix, L. Walløe and Ø. Ulltang (eds). *Whales, seals, fish and man.* Elsevier, Amsterdam: 337-349..

Hammill, M.O. and Gosselin, J.F. (in press). Female reproductive rates, age at first birth, and age of maturity in male grey seals (*Halichoerus grypus*) from the northwest Atlantic. *Can. J. Fish. Aquat. Sci.*

Hammill, M.O., Stenson, G., Myers, R.A. and Stobo. W. (in manuscript). Population trends of the grey seal (*Halichoerus grypus*) in the Gulf of St Lawrence. Submitted, *Can. J. Fish. Aquat. Sci.*

Härkönen, T. 1986. *Guide to the otoliths of bony fishes of the northeast Atlantic.* Danbiu ApS, Hellerup. 256 pp.

Harwood, J., Anderson, S.S. and Curry, M.G. 1976. Branded grey seals (*Halichoerus grypus*) at the Monach Isles, Outer Hebrides. *J. Zool.* 180: 506-508.

Harwood, J. and Prime, J. 1978. Some factors affecting the size of British grey seal populations. *J. appl. Ecol.* 15: 401-411.

Haug, T., Henriksen, G., Kondakov, A., Mishin,V., Nilssen, K.T. and Røv, N. 1994. The status of grey seals *Halichoerus grypus* in North Norway and on the Murman coast, *Russia. Biol. Conserv.* 70: 59-67.

Haug, T., Henriksen, G., Nilssen, K.T. and Ørjebu, A. 1991. Recent studies of the distribution and abundance of grey seal *Halichoerus grypus* in North Norway, and their possible influence on parasitic infestations in fish.ICES CM 1991/N:2.21 pp.

Hiby, L. 1995. The use of automated pattern matching in a demographic study of grey seals. Abstract, Eleventh Biennial Conference on the Biology of Marine Mammals. Orlando, Dec. 1995.

Hiby, L., Duck, C. and Thompson, D. (in manuscript). The use of aerial photography to monitor pup production of grey seals (*Halichoerus grypus*) in Scotland. Submitted, *J. Appl. Ecol.*

Hiby, A.R., Thompson, D. and Ward, A.J. 1988. Census of grey seals by aerial photographs. *Photogram. Rec.* 12: 589-594.

Iverson, S.J., Bowen, W.D., Boness, D.J. and Oftedal, O.T. 1993. The effect of maternal size and milk energy output on pup growth in grey seals (*Halichoerus grypus*). *Physiol. Zool.* 66: 61-88.

Johannesen, Ó.G. 1976. Kópaveiða i Dali. *Mondul* 1976(2): 7-9.

Katona, S.K., Rough, V. and Richardson, D.T. 1993. *A field guide to whales, porpoises and seals from Cape Cod to Newfoundland.* Smithsonian Institute, Washington DC. 316 pp.

Landt, J. 1800. Om Sælhundefangst.in *Forsøk til en beskrivelse over Færøerne.* Tidsjob Forlag, København:214-16.

Lavigueur, L. and Hammill, M.O. 1993. Distribution and seasonal movements of grey seals, *Halichoerus grypus*, born in the Gulf of St Lawrence and eastern Nova Scotia shore. *Can. Field Nat.* 107: 329-340.

Marcogliese, D.J. and Boily, F. (in manuscript). Distribution and abundance of stomach nematodes among grey seals (*Halichoerus grypus*) in the Gulf of St Lawrence. Submitted, *Can. J. Fish. Aquat. Sci.*

McClelland, G., Misra, R.K. and Martell, D.J. 1985. Variations in abundance of larval Anisakines, sealworm (*Pseudoterranova decipiens*) and related species in eastern Canadian cod and flatfish. *Can. Tech. Rep. Fish. Aquat. Sci.* No 1392. 57 pp.

McClelland, G., Misra, R.K. and Martell, D.J. 1990. Larval anisakine nematodes in various fish species from Sable Island Bank and vicinity, in W.D. Bowen (ed). Population biology of sealworm (Pseudoterranova decipiens) in relation to its intermediate and seal hosts. *Can. Bull. Fish. Aquat. Sci.* No 222:83-118.

McConnell, B.J., Chambers, C., Nicholas, K.S. and Fedak, M.A. 1992. Satellite tracking of grey seals (*Halichoerus grypus*). *J. Zool.* 226:271-282.

Mansfield, A.W. and Beck, B. 1977. Grey seals in eastern Canada. *Fish. Mar. Serv. Tech. Rep.* No 704. 81 pp.

Marcogliese, D.J. and McClelland, G. 1994. The status of biological research on sealworm (*Pseudoterranova decipiens*) in eastern Canada. *Can. Ms. Rep. Aquat. Sci.* 2260. viii + 26 pp.

Mohn, R. and Bowen, W.D. 1994. A model of grey seal predation on 4VSW cod and its effects on the dynamics and potential yield of cod. DFO Atl. Fish.Res. Doc.94/75. 25 pp.

Murie, D.J. and Lavigne, D.M. 1992. Growth and feeding habits of grey seals (*Halichoerus grypus*) in the northwestern Gulf of St Lawrence, Canada. *Can.J. Zool.* 70: 1604-1613.

Nicholas, K.S., Fedak, M.A. and Hammond, P.S. 1992. An automatic recording station for detecting and storing radio signals from free ranging animals. In I.G. Priede & S.M. Swift (eds). *Wildlife Telemetry: remote monitoring and tracking of animals.* Ellis Horwood. Chichester:76-78

Pomeroy, P.P., Anderson, S.S., Twiss, S.D. and MocConnell, B.J. 1994. Dispersion and site fidelity of breeding female grey seals (*Halichoerus grypus*) on North Rona, Scotland. *J. Zool.* 233: 429-447.

Preust, F. 1996. Composition du regime alimebtaire du phoque gris (Halichoerus grypus) dans le Golfe du Saint-Laurent, Quebec, Canada. Memoire de Maitrise Presente a l'UniversitÚ du Quebec a Rimouski.

Prime, J.H. and Hammond, P.S. 1987. Quantitative assessment of grey seal diet from faecal analysis. In A.C. Huntley, D.P. Costa, G.A.J. Worthy and M.A. Castellini (eds). *Approaches to Marine Mammal Energetics.* Society of Marine Mammalogy, Special Publication No 1. Allen Press, Lawrence:161-181

Prime, J.H. and Hammond, P.S. 1990. The diet of grey seals from the southwestern North Sea assessed from analyses of hard parts found in faeces. *J. appl. Ecol.* 27: 435-447.

Reinert, A. 1982. Havert omkring Færøerne. In A. Nørrevang and J. Lundø (eds). *Danmarks Natur. Færøerne*, 12: 55-58

Scott, D.M. and Fisher, H.D. 1958. Incidence of the ascarid *Porrocaecum decipiens* in the stomachs of three species of seals along the southern Canadian Atlantic mainland. *J. Fish. Res. Bd Can.* 15: 495-516.

Sjøberg, M., Hunter, C., McConnell, B.J. and Fedak, M.A. 1993. Movements, diving behavior of grey seal (*Halichoerus grypus*) in the Baltic. Abstract, Tenth Biennial Conference on the Biology of Marine Mammals. Galveston, Texas, Nov. 1993.

Stobo. W.T., Beck, B. and Fanning, L. 1990. Seasonal sealworm (*Pseudoterranova decipiens*) abundance in grey seals (*Halichoerus grypus*). In W.D. Bowen (ed). Population biology of sealworm (*Pseudoterranova decipiens*) in relation to its intermediate and seal hosts. *Can. Bull. Fish. Aquat. Sci.* No 222: 147-162

Stobo, W.T. and Zwaneneburg, K.C.T. 1990. Grey seal (*Halichoerus grypus*) pup production on Sable Island and estimates of recent production in the northwest Atlantic. In W.D. Bowen (ed). Population biology of sealworm (*Pseudoterranova decipiens*) in relation to its intermediate and seal hosts. *Can. Bull. Fish. Aquat. Sci.* No 222: 171-184

Stobo, W.T., Beck, B. and Horne, J.K. 1990. Seasonal movements of grey seals (*Halichoerus grypus*) in the northwest Atlantic. In W.D. Bowen (ed). Population biology of sealworm (*Pseudoterranova decipiens*) in relation to its intermediate and seal hosts. *Can. Bull. Fish. Aquat. Sci.* No 222: 199-213

Templeman, W. 1990. Historical background to the sealworm problem in eastern Canadian waters. In W.D. Bowen (ed). Population biology of sealworm (*Pseudoterranova decipiens*) in relation to its intermediate and seal hosts. *Can. Bull. Fish. Aquat. Sci.* No 222: 1-16.

Twiss, S.D., Pomeroy, P.P. and Anderson, S.S. 1994. Dispersion and site fidelity of breeding male grey seals (*Halichoerus grypus*) on North Rona, Scotland. *J. Zool.* 233: 683-693.

Wiig, Ø. and Øien, N. 1987. Recoveries of grey seal *Halichoerus grypus (Fabricius)* tagged along the Norwegian coast. *Fauna norv.*, Ser. A, 8: 39-42.

Zwanenburg, K.C.T. and Bowen, W.D. 1990. Population trends of the grey seal (*Halichoerus grypus*) in Eastern Canada. In W.D. Bowen (ed). Population biology of sealworm (*Pseudoterranova decipiens*) in relation to its intermediate and seal hosts. *Can. Bull. Fish. Aquat. Sci.* No 222: 185-197.

List of Participants

Dorete Bloch
Museum of Natural History
Fútalág 40
FR-100 Tórshavn, Faroe Islands
Tel.: +298 18588
Fax: +298 18589
Email: doreteb@ngs.fo

Arne Bjørge (Chairman)
NINA, P.O.Box 736, sentrum
N-0315 Oslo, Norway
Tel.: +47 22 94 03 71
Fax: +47 22 94 03 01
Email: arne.bjørge@bio.uio.no

Mike Hammill
Department of Fisheries & Oceans
P.O. Box 1000, Mont Joli (Quebec)
G5H 3Z4 Canada
Tel.: +1 418 775 0580
Fax: +1 418 775 0542
Email: m_hammill@am.qc.dfo.ca

Tore Haug
Norwegian Institute of
Fisheries and Aquaculture
P.O.Box 2511,
N-9037 Tromsø, Norwau
Tel.: 77 62 92 20
Fax: 77 62 91 00
Email: toreh@fiskforsk.norut.no

Erlingur Hauksson
Icelandic Fisheries Laboratories
Skúlagata 4
IS-101 Reykjavik, Iceland
Tel.: +354 56 20240
Fax: +354 56 20740
Email: erlingur@rfisk.is

Bjarni Mikkelsen
Norwegian Institute of
Fisheries and Aquaculture
P.O.Box 2511,
N-9037 Tromsø, Norwau
Tel.: 77 62 92 20
Fax: 77 62 91 00

Nils Øien
Institute of Marine Research
P.O.Box 1870,
N-5024 Nordnes, Bergen
Tel.: +47 55 23 86 05
Fax: +47 55 23 83 87
Email: nils@imr.no

Jóhann Sigurjónsson
Marine Research Institute
P.O.Box 1390
IS-121 Reykjavik, Iceland
Tel.: +354 55 20240
Fax: +354 5 623790
Email: johann@hafro.is

David Thompson
Sea Mammal Research Unit
c/- British Antarctic Survey
High Cross, Madingley Road
Cambridge, CB3 0ET
UK
Tel.: +44 1223 311354
Fax: +44 1223 328927
Email: DTH@wpo.nerc.ac.uk