ICES Advisory Committee on Fishery Management
ICES CM 2004/ACFM:06

Report of the ICES/NAFO Working Group on Harp and Hooded Seals

2–6 September 2003
Arkhangelsk, Russia

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

Palægade 2–4 DK–1261 Copenhagen K Denmark
Telephone + 45 33 15 42 25 · Telefax +45 33 93 42 15
www.ices.dk · info@ices.dk

TECHNICAL MINUTES

Joint ICES/NAFO Working Group on Harp and Hooded Seals (WGHARP)

ACFM October 2003

Present:

Sub-group chair: Henk Heessen
Presenter: Tore Haug (WG Chair)
1st Reviewer: Tomas Saat
2nd Reviewer: Alain Biseau (rapporteur)
Participation: Poul Degnbol
Hans Lassen

General comments

The report of WGHARP is well organised, and easy to read. The sections on biological issues are very informative for non-specialists.

Experiments with satellite tags should be encouraged to get better information on distribution and migration, and thus on stock identity. In this respect, also genetic studies could be promising.

The review of the seal diet and consumption studies (as requested in ToR b) was considered very interesting
The great amount of work done during the WG meeting and prior to it was acknowledged, especially for the biological studies and for the development of a new assessment model.

In future reports the WG is requested to present all input data used for the assessment models (e.g. the age compositions that were used).

Since the status of the stocks is not well known (in the absence of Biological Reference Points), no management advice could be given, but some technical results for several levels of harvesting will be included in the ACFM report.
The Sub-Group supported the WG recommendations and especially the need for having a pup survey every 5 years.

Biological Reference Points

The framework presented to formalise/define Biological Reference Points was clear, with different harvest control rules for each level of abundance.

In the proposal two precautionary reference points were distinguished but comments were raised on the definition of the upper point (N_{70}). This should rather be considered as a target point than as a precautionary reference point.

It was pointed out that proposing limit reference points is clearly the responsibility of scientists and that proposed reference points include uncertainties. Identifying target reference points is the responsibility of managers and when target reference points are decided, economic aspects are usually taken into consideration.
It was considered that it would be very difficult to properly define an upper stock limit (K). It may not be pertinent for all stocks to set this upper limit at the largest observed level of the stock. This should be looked at on a case by case basis. In the presented framework (based on an example from the Northwest Atlantic) all reference points are derived from this upper limit (N70%, N50%, N30%). In some cases it might be worthwhile to define the lower limit (limit reference point) first and to derive the other points from that limit.

The rationale behind the choice of different levels (in this example N70, N50, N30) should be further developed, and these levels (percentages) should be defined stock by stock.

The Sub-Group supported the decision taken by the WG to use abundance in numbers and not biomass as the metric to set Biological Reference Points.

The use of the Potential Biological Removal (PBR) in data poor situations should be encouraged.
It would have been interesting if values of Biological Reference Points had been calculated for some of the stocks as an illustration of the proposed framework, even though discussion and reflection should continue before formal proposals for Biological Reference Points can be made.

The model

The subgroup acknowledged the work done by the WG to present the model used. However, comments were raised on the choice of a model dealing with 20 age classes whereas uncertainties exist in the age estimation (sampling and age reading, and backward estimation of the age composition of catches over the whole time series).

The pros and cons should be explained more thoroughly, since the WG changed from a very rough but probably more robust model with only two age-groups and a small number of parameters in the previous assessment to a much more sophisticated model with a greater number of age groups, but probably a better fit. Having said that, a model should be adequate for the data available. The Sub-Group was unable to comment on which model would be most adequate. In this respect, a comparison of the results of both models would have been helpful.
Concern was expressed by the fact that the level of natural mortality used in the new model was actually estimated by the old model. The Sub-Group, however, fully supported the further development of the model to allow the inclusion of an estimation of M in the fitting procedure.
It would be welcomed if in the report a more clear distinction was made between parameters which are input data (and if it had been mentioned which were based on assumptions and which were estimated), and which are output values. For instance, the status of N_{1945} was not very clear. First it is said that N_{1945} is taken from estimates obtained from the previous model, and then it is said that N_{1945} is the only parameter that is estimated.
The procedure to rebuild the age composition (over 20 ages) and the assumptions which allowed to do so, should be clearly stated. The assumption of a ‘stable’ age structure should be clarified. Furthermore, the assumption that the age composition of the catches is the same as in the population should be discussed. Is there a reason to assume the same rate of harvesting for each of the 20 age groups? The same remark holds for the assumption on the sex-ratio (= 0.5). Is there evidence for that?
The expression ‘sustainable catch’ raised some questions, since it had been considered as the stabilisation of the current population size (D1+ ~ 1). This interpretation was considered to be rather arbitrary and potentially misleading since the current level may be far from an MSY type level. In this respect the Terms of Reference for the WG should be explained more precisely in order to avoid any ambiguity.
The SG had concerns about the confidence interval shown in the report for D1+ (Table 9 and 10). Even though it represents only a very small part of the real uncertainty, such narrow confidence intervals are probably not correct.
The new predictions appear to be lower than those based on the previous assessment. The inclusion of more uncertainties in the model makes the result more conservative. This is not explained clear enough in the report.
Finally it should be explained why the values for natural mortality in the Greenland harp seal stock (M = 0.12) and in the White Sea stock (M = 0.09) are different.

CONTENTS

1 TERMS OF REFERENCE

In 1984 an ICES Working Group on Harp and Hooded Seals in the Greenland Sea was established (C.Res.1984/2:4:18); meetings were held in September 1985 and October 1987 (ICES Coop. Res. Rep. 148 and ICES CM 1988/Assess:8). In 1988 the terms of reference were expanded to include harp seals in the White and Barents Seas (C.Res. 1988/2:4:27), and the Working Group met in October 1989 (ICES CM 1990/Assess:8).

In 1989 it was recommended that a Joint ICES/NAFO Working Group on Harp and Hooded Seals (WGHARP) be established, with the following mandate (C.Res. 1989/3:1):

> " ... for the purpose of assessing the status of these stocks and providing related advice and information in the areas of both organisations. Contracting Parties to either organisation or regulatory commissions who might desire advice on harp and/or hooded seals in a particular geographical area must refer their request to the organisation (NAFO or ICES) having jurisdiction over or interest in that area. Advice based on reports of the Joint Working Group would be provided by ACFM in the case of questions pertaining to the official ICES Fishing Areas (FAO Area 27) and by NAFO Scientific Council in the case of questions pertaining to the legally-defined NAFO area. ICES will administrate the Joint Working Group in terms of convening meetings, formulating terms of reference, handling membership and chairmanship, and processing, printing, and distributing Working Group reports."

Following a request from Norway, WGHARP met for the first time in October 1991 (ICES CM 1992/Assess:5).

WGHARP did not meet in 1992, but based upon its recommendation an ICES/NAFO Workshop on Survey Methodology for Harp and Hooded Seals was held 5–12 October 1992 in Arkhangelsk, Russia (ICES CM 1993/N:2).

WGHARP met in September 1993 to assess the Greenland Sea stocks of harp and hooded seals, and to give advice for the 1994 sealing season in that area (ICES CM 1994/Assess:5). The Working Group met again in June 1995 to assess the harp and hooded seal stocks in the Northwest Atlantic, and to evaluate the impact of environmental changes and ecological interactions for all North Atlantic stocks of the two species (NAFO SCR Doc. 95/16).

Based on a request from NAMMCO in May 1995, and on questions that arose from its 1993 meeting, WGHARP met in August/September 1997 to provide assessment advice on harp seals in the White Sea and Barents Sea, and harp and hooded seals in the Greenland Sea; to review existing population models for harp seals in order to standardise the methodology used to estimate numbers at age; to assess current information on the effect of recent environmental changes or changes in the food supply on harp and hooded seals, and review available data on the possible interaction between these seal species and other living marine resources (ICES CM 1998/Assess:3). The Working Group was, however, unable to deal with the entire request, and met again in September/October 1998 to complete the assessment work with harp seals in the White Sea/Barents Sea and hooded seals in the Greenland Sea (ICES CM 1999/ACFM:7).

Based on a request from the Joint Norwegian-Russian Fisheries Commission, and on some outstanding questions from the 1998 meeting, WGHARP met in October 2000 to provide assessment advice on harp seals in the White Sea / Barents Sea and on harp and hooded seals in the Greenland Sea; to discuss the appropriateness of current and other possible biological reference points for harp and hooded seals; to summarise new information on predation on commercially important fish stocks by the same two seal species; and to agree on objectives and presented plans for a forthcoming Workshop on Population Modelling of Pinnipeds (ICES CM 2001/ACFM:8).

Based on a request from the Joint Norwegian-Russian Fisheries Commission, and on some outstanding questions from the 2000 meeting, ACFM formulated the following terms of references for WGHARP (Chair: Prof. T. Haug, Norway) to deal with when it met at SevPINRO in Arkhangelsk, Russia from 2–6 September 2003:

a) review of recommendations from the "Workshop to Develop Improved Methods for Providing Harp and Hooded Sea Harvest Advise", possibly also apply recommended models to existing data on harp and hooded seals;

b) review and discuss existing methods applied in seal diet and consumption studies;

c) review results from surveys of the 2002 harp and hooded seal pup production in the Greenland Sea;

d) calculate biological limits of yields for Greenland Sea harp seals, Greenland Sea hooded seals, and White Sea / Barents Sea harp seals – these limits should reflect very low risk of collapse;

e) assess the impact of stock development of annual harvest of: a) current catch levels, b) sustainable catches, c) twice the sustainable catches – if possible, these impacts should be presented as medium term projections (10 years)

Items d) and e) were formulated to provide ACFM with the information required to respond to the requests for advice/information from the Joint Norwegian-Russian Fisheries Commission. WGHARP will report at the 2004 Annual Science Conference and to ACFM at its October 2003 meeting. Furthermore WGHARP will report to the NAFO Scientific Council at its meeting in the fall of 2003.

2 MEETING ARRANGEMENTS

The Working Group, chaired by T. Haug, and comprised of scientists from Canada, Greenland, Norway, Russia, and USA met at SevPINRO, Arkhangelsk, Russia, 2 to 6 September 2003. A list of participants is given in Appendix I.

The Working Group reviewed the report from the "Workshop to Develop Improved Methods for Providing Harp and Hooded Sea Harvest Advice", and available information on catches and relevant scientific information on harp and hooded seals, including documents prepared for this meeting. In addition, information on the precautionary approach and biological reference points were reviewed. The Agenda adopted for the meeting is shown in Appendix II, and the papers referred to are listed in Appendix III. Hammill, Merrick, Nilssen and Stenson agreed to assist the Chair as rapporteurs.

3 Review of recommendations from the Workshop to Develop improved methods for providing harp and hooded seal harvest advice

After evaluating its history of providing advice on harp and hooded seal harvests in the North Atlantic WGHARP felt the need to re-evaluate its approaches to harvest modelling for the two species. For this reason, a workshop to "Develop Improved Methods for Providing Harp and Hooded Seal Harvest Advice" was convened in Woods Hole, Massachusetts, USA on 11-13 February 2003 (ICES 2003). The workshop included 21 participants including invited experts in population modeling and WGHARP members. The workshop was charged with:

- Reviewing methods used to assess population status and provide management advice
- Exploring alternative methods used to assess marine mammal status and provide management advice
- Providing advice on model formulations that could be used under different levels of data availability
- Exploring available reference points and determine applicability to harp and hooded seals
- Providing advice on applicability of these models and reference points to other pinniped species
- Consideration of 1) density dependent vs. non-density dependent models, 2) differing management goals, 3) differing legal structures

Over the three day period, presentations were made on harvest management regimes employed on a variety of marine mammal species worldwide and considerable discussion ensued relating to the current WGHARP models and the applicability of the precautionary approach to managing harp and hooded seal harvests.

Recommendations from the Workshop were as follows:

a) Comparison of Model Formulations
   i) Run the Northeast Atlantic (NE) model on Northwest Atlantic (NW) data
   ii) Run NE model against simple replacement yield model using the NE data
   iii) Run NE model against the 'Ulltang' model (old WGHARP NE Atlantic model) using the NE data

b) Should there be one model or more?
   i) More than one model should be used (at least for now) with NW and NE models continuing to be used
   ii) Model form will depend upon the data available, but should use as much data as possible
   iii) The NW model is for replacement yield while the NE is for sustainable yield. For transparency and comparability, both models should be designed to achieve the same yield.

c) Advice on Model Formulations – Sensitivity Simulations
   i) Run NE model starting in 20th Century (w/out K assumption)
   ii) Run NE model removing different parameters to see how removing data affects model output (which data are critical; how data poor can we be and still have an effective model)
   iii) Evaluate sensitivity to input parameters – age at maturity and late-term pregnancy rates. Also, test the assumption that age samples from the whelping grounds are representative for mature females.
   iv) Evaluate how important a valid age structure is to the NE model and, if found to be important, increase priority of collecting these data. There was disagreement as to whether the existing age-structure data are representative of whelping females or the population.
   v) Track survival rates for realism
   vi) Consider running simulations on both the real datasets and simulated datasets (*Pagophilus electronica*), and consider contacting other simulation experts for advice
   vii) Density Dependence - If you have data, use it and don't specify density dependence separately. If you don't have data and you incorporate it and test the model sensitivity (run with and without)

d) Suitability of IWC's RMP and MMPA's PBR as alternative model forms
   i) The RMP and PBR approaches are based on different management objectives which probably would not satisfy the ICES/NAFO objectives in most cases (though there may be situations where the PBR approach could be applied to data poor species)
   ii) However, WGHARP should consider the process used to develop these approaches and implementation frameworks as a potential management framework

e) Data Requirements
   i) The primary data needs are for:
      (1) Pup production on regular intervals,
      (2) Reproductive rates,
      (3) Harvest numbers by stage, and
      (4) Age composition of the population and/or harvest.
   ii) Most of the data are of high priority for collection (age composition may be an exception)
   iii) Existing models can get by with limited data but the full suite of data is ultimately needed. Also, there are differences in the data that are needed for modelling and management.

f) Management Framework
   i) WGHARP needs to further discuss the distinction between assessment models and management framework
   ii) A management framework for harp and hooded seals needs to be developed which incorporates the biological reference points (this likely requires advice from ACFM)

g) Biological Reference Point Recommendations
   iii) Abundance (N) rather than Biomass (B) should be used for marine mammal biological reference points, where N could be: total population, total pups born, or mature females
   iv) N_{LIM} can be defined,
   v) N_{MSY} is probably not practical for marine mammals (though it can be defined in theory for seals)
   vi) Biological reference points should index N_{MAX} not K (and also not N_{CRIT})
   vii) There are several options to defining N_{LIM} including DFO's $N_{CRIT(30\%);}$ IWC's 54% of K (number of mature females) as a protection level; USA's endangered classification under the ESA; and certain Fishery definitions like B_{20} to B_{40} (Australia, US). The participants recommended against use of N_{LOSS} and N_{MSY}.
   viii) Set one or more N_{PA} between N_{REF} and N_{LIM}
   ix) Set and implement control rules which will be associated with N_{LIM} and N_{PA}

WGHARP remanded the modelling recommendations to a modelling subgroup for prioritization. This group consisted of Bøthun, Harbitz, Golikov, Korzhev and Skaug.

With respect to recommendations on biological reference points (BRPs), WGHARP agrees with the recommendations in principle, but acknowledges that development of a final set of BRPs will require considerable additional deliberation by group. Further discussions of this issue and an interim set of recommendations on BRPs are provided in Section 6 of this report.

4 HARP SEALS (Pagophilus groenlandicus)

4.1 Stock Identity, Distribution and Migration

The names of the different populations used by the working Group were discussed. The current names were agreed upon to reduce the extensive use of local names for the different populations. In order to clarify nomenclature, names were chosen that reflect the general distributions of each population. It was proposed to shorten the name of the White Sea/Barents Sea stock to 'White Sea". The Chair will raise this issue with ACFM to determine if there are conventions for naming stocks or for changing them.

Haug described the results of a recent study on the movements of adult harp seals tagged in the Greenland Sea with satellite linked time depth recorders. Eleven adult harp seals (male and female) were equipped with satellite transmitters after moulting in the Greenland Sea in 1999 (Lars Folkow, AAB/IMB, University of Tromsø, Norway, pers. comm.). The results showed that many of the animals migrated to and stayed in the northern parts of the Barents Sea around and to the east of the Svalbard archipelago in the period July-December, to a lesser extent also in April. In January-March their occurrence was confined to the Denmark Strait and the Greenland Sea, where some of the animals stayed during the entire tagging period. While the seals spent much of their time in close association with the pack-ice, occurrence in open waters appeared to be quite common, particularly during summer and early autumn.

The Working Group noted that there are likely to be interannual differences in migration and therefore, additional deployments are required to determine inter-annual variation. These studies provide exceptionally interesting information, but it must be remembered that they are based on a very small sample (n=11) of adults. Also, movements of other age groups are unknown

Nilssen presented preliminary results of a joint Norwegian/Russian study of marine mammal distribution in the Barents Sea (Zabavnikov et al. 2002). This study was based upon aerial surveys in Sept and October 2002 conducted from the Russian aircraft 'AN-26 Arktika'. The main conclusions were that harp seals were only observed near the ice edge which was north of the major areas of capelin and polar cod (*Boreogadus saida*) distributions. In contrast, cetaceans were observed in areas of high capelin abundance. This confirms the findings of preliminary surveys in September 2001 which also concluded that there was no evidence of overlap between harp seals and capelin. However, in 2001 poor weather prohibited surveys of areas around Frans Joseph Land. Thus, there was no evidence that large numbers of harp seals migrated to areas of capelin abundance at this time of the year.

Zharikov described the results of aerial surveys carried out in the Barents Sea from 1979-1985 during which data on distribution of pelagic marine mammals were collected. All surveys were conducted in the period from late August to early October using an Il-18 aircraft flying at 200-400 m with a speed of 340-360 km/hour. The main goal of the surveys was to locate dense fish schools for commercial harvest; marine mammal distribution was a secondary objective and attention was not paid to species identification. It was assumed that sightings marked as just "seal" were likely harp seals. Most marine mammal concentrations in all years were found in the waters to the southeast of Svalbard and near Hopen Island, while lower densities were observed in the very central part of the Barents Sea. No animals were sighted in the southern part. Northern waters and the ice edge were not surveyed. An abnormal shift was observed in 1982, when there were no seals in the central part but instead, a large number were observed in the eastern waters closer to Novaya Zemlya. This was probably due to the relatively high water temperatures in 1982 which resulted in changes in the spatial distribution of prey species. Additional analysis is required to estimate the degree of association of harp seal aggregations with different fish schools and the impact of abiotic factors on marine mammal distribution in given years.

Haug presented a figure that was produced some time ago describing the general patterns of White Seal/Barents Sea harp seals based on anecdotal sighting and non directed surveys. Preliminary results of satellite tracking show a similar pattern indicating the usefulness of such sighting data. However, it was pointed out that satellite transmitters also provide dive data that are useful for other purposes.

Stenson informed the working group that a study is currently underway at Memorial University of Newfoundland that is exploring stock structure of harp seals using Mitochondrial and microsatellite DNA analyses. The results should be available at the next meeting.

4.2 The Greenland Sea Stock

4.2.1 Information on recent catches and regulatory measures

Available information on Norwegian catches of harp seals in the Greenland Sea from 2001 thru 2003 are listed in Appendix IV, Table 2. The total catches were 2,992 (including 2,267 pups), 1,232 (1,118 pups) and 2277 (161 pups) animals in 2001, 2002 and 2003, respectively. Removals were 4-15% of the allocated quotas, which was 15,000 animals one year old or older (1+ animals). Parts of, or the whole quota, could be taken as weaned pups assuming 2 pups equalled one 1+ animal. Russia has not participated in this hunt since 1994.

Available information on Norwegian and Russian sealing effort in the Greenland Sea is given in Appendix IV, Tables 3 and 4.

4.2.2 Current research

Satellite tags were deployed in a Norwegian experiment on newly moulted harp seals captured in the Greenland Sea in 1999 (see 4.1). These data have been analyzed and submitted for publication. Furthermore, Norwegian scientists collected data on the condition of adults and pups in the whelping areas in 2001. Biological samples were collected during the commercial hunt in 2000 and 2001 to determine the age structure of the harvest. However, 1+ animals comprise only a small proportion of the harvest.

Norway has also conducted a project in 1999-2002 to estimate the ecological importance of harp seals in the Greenland Sea (Haug et al. 2002). Samples were collected throughout the year (summer, fall, winter) to estimate body condition and diet composition using stomach contents, fatty acid and stable isotope analysis. Analyses of the collected material are in progress.

In March / April 2002, Norwegian aerial surveys were carried out in the Greenland Sea pack-ice (the West Ice), to assess the pup production of the Greenland Sea population of harp seals (see 4.2.4).

4.2.3 Biological parameters

Frie *et al*. (2003) presented the results of a study of trends in mean age of sexual maturity (MAM) of female harp seals in the Greenland Sea. These data were presented to the WG previously ((ICES CM 2001/ACFM:8; SEA-101). No differences were observed in MAM among samples collected in 1959-1964, 1978, 1987 and 1990. However, samples in 1991 showed a significant increase in MAM. It is unlikely that the large increase from 1990 to 1991 reflects a real change in maturity and may be an artefact of a biased age structure from sampling female seals during the moulting period. Confining the analysis to animals sampled at the same time of the year still resulted in a significant difference in 1991. There is also the possibility that spatial segregation among animals of different reproductive status occurred, but this could not be tested.

Svetochev informed the Working Group that he was present during the sampling in 1990 and 1991 and indicated that there may be additional data from both years. The files will be examined to see if any such data are available.

Preliminary results of an experiment to compare methodology and results of age determination readings of harp seal teeth by Norwegian and Russian readers are presented in Frie *et al*. (this meeting, SEA-131). The method of tooth preparation is similar in Norway and Russia although Russian scientists tend to cut the tooth lower than Norwegians. A number of differences were observed between readers. It was noted that both of the Norwegian readers do not have a lot of experience which may account for some of the differences. Examining known-aged seals indicates that age estimates should be looked upon as distributions rather than as point estimates. Comparing Norwegian readings of teeth previously read by a Russian reader suggests that the Norwegian readers may be assigning higher ages to seals up to the age of 10 years. The Russian reader also read teeth previously read by an experienced Norwegian reader. Generally, the Russian reader assigned younger ages to seals previously aged at 1-2 years and for older seals > 10 years.

It was noted that the Russian reader was close or a little higher for known-aged animals and yet she was lower than the experienced Norwegian reader. This may have an impact of the age classes used in studies of sexual maturity. The Working Group agreed that this pilot study should be continued. There are additional known-aged teeth, including many older animals, in the different laboratories. These teeth should be included in an expanded study of reading errors. The use of decalcified and thin sectioned teeth should also be considered. It has been shown to improve age readings in other species such as ringed seals. The use of considering other data such as length could also be explored.

The WG requested that each lab check to see if there are any known-aged teeth that have not been sectioned that could be used in a comparison between readings of calcified and decalcified teeth.

4.2.4 Population assessment

Pup production

From 14 March to 6 April 2002 aerial surveys were carried out in the Greenland Sea pack-ice (the West Ice), to assess the pup production of harp seals (Haug *et al.*, this meeting, SEA-116). One fixed-wing twin-engined aircraft (stationed in Scoresbysound, Greenland, but also permitted to use the Jan Mayen Island as a base) was used for reconnaissance flights and photographic surveys along transects over the whelping patches once they had been located and identified. A helicopter, stationed on and operated from the research vessel (R/V"Lance"), assisted in the reconnaissance flights, and subsequently flew visual transect surveys over the whelping patches. The helicopter was also used for age-staging of the pups, performed along transects over the patches. Three harp seal breeding patches (A, B and C) were located and surveyed either visually and/or photographically. The total estimate of pup production, including a visual survey of Patch A, both visual and photographic surveys of Patch B, and a photographic survey of Patch C, was 98 099 (SE=20 419.1), giving a coefficient of variation for the survey of 20.4%.

The Working Group noted that these estimates are preliminary, and need to be corrected for areas not photographed. This is unlikely to affect the estimate of Patch B significantly but could affect the overall estimate for Patch C. Also the application of the birthing ogive should be described in more detail and its applicability to patch A be explored. Finally, there were no data available to correct for pups that may have been born after the survey of Patch C or left the ice. Although the late date of the survey suggests that most of the pups had been born before the survey, it is possible that some pups had left the ice. Therefore the estimates are likely to be negatively biased.

The WG also suggested that experiments be carried out to determine the relationship between counts made by observers during visual surveys to estimate potential biases and determine the accuracy of the estimates

Population model

At the previous meeting of the Working Group population assessments were presented based on a population dynamics model originally described by Skaug and Øien (ICES CM 2001/ACFM:8). Bøthun *et* al. (this meeting, SEA-132) presented a new population model that estimates the current total population size using the historical catch data and estimates of pup production. These estimates are then projected into the future to provide a future population size for which statistical uncertainty is provided for each set of catch options.

There were several significant differences between the current model and the one used at the last meeting (ICES CM 2001/ACFM:8). The previous model used only two age classes (pups and 1+ animals), while the new model uses 20 age classes. Work carried out following the previous meeting indicated that the earlier model was less appropriate than a model with a full age structure. Also, the model used in 2000 attempted to estimate the uncertainty in M_0, M_{1+} and F. In contrast, estimation of mortality (M_0 and M_{1+}) and a birth rate among mature females (F) has yet not been built into the current model, and hence the uncertainty associated with these parameters is not accounted for in the assessment. Thus the variance estimates provided by this model are negatively biased and caution should be taken when evaluating the uncertainty associated with the output.

The same population dynamic model was used for all three of the northeast Atlantic populations, but with stock specific values of biological parameters. The parameters of the model are:

$N_{0,t}$	=	number of pups born in year t,
$N_{i,t}$	=	number of individuals at age i in year t,
N_{1945}	=	Population size in 1945,
M_0	=	pup mortality,
M_{1+}	=	Mortality among 1+ animals,
$p_{i,t}$	=	proportion of females at age I being reproductively active in year t
F	=	birth rate among reproductively active females,

Values for M0, M1+ and N_{1945} are taken from the estimates obtained from the previous model (ICES CM 2001/ACFM:8).

It is assumed that the population had a stable age structure in year t_0 = 1945, i.e.

$$N_{i,t_0} = N_{1945} \cdot e^{-(i-1)M_{1+}}(1-e^{-M_{1+}}), \qquad i=1,\dots,A-1$$
$$N_{A,t_0} = N_{1945} \cdot e^{-(A-1)M_{1+}}$$

The maximal age group A=20 contains all individuals aged A or more. The catch records give information about the following quantities:

$$C_{0,t} = \text{catch in numbers of pups in year } t,$$
$$C_{1+,t} = \text{catch in numbers of 1+ animals in year } t.$$

Due to the lack of information about age specific catch numbers for adults (for the years with high catch levels) the following pro-rata rules were employed in the model:

$$C_{i,t} \; = \; C_{1+,t}\frac{N_{i,t}}{N_{1+,t}}, \qquad i = 1,\dots,A$$

Catches are assumed to have been taken prior to the occurrence of natural mortality, leading to the following set of recursion equations:

$$\begin{aligned} N_{1,t} &= \left(N_{0,t\text{-}1} - C_{0,t\text{-}1}\right)e^{\text{-}M_0} \\ N_{i,t} &= \left(N_{i\text{-}1,t\text{-}1} - C_{i\text{-}1,t\text{-}1}\right)e^{\text{-}M_{1+}}, \qquad i = 2,\dots,A-1, \\ N_{A,t} &= \left(\left(N_{A\text{-}1,t\text{-}1} - C_{A\text{-}1,t\text{-}1}\right) + \left(N_{A,t\text{-}1} - C_{A,t\text{-}1}\right)\right)e^{\text{-}M_{1+}}. \end{aligned}$$

The pup production is given as

$$N_{0,t} = \frac{F}{2}\sum_{i=1}^{A} p_{i,t}N_{i,t},$$

where $N_{i,t}/2$ is the number of females at age i.

The mean birth rate for 1+ females in year t is calculated as

$$f_t = F\frac{\sum_{i=1}^{A} p_{i,t}N_{i,t}}{\sum_{i=1}^{A} N_{i,t}}$$

The only parameter that is estimated is N_{1945} (the population size in 1945). The estimate of N_{1945} was obtained by minimizing the weighted (according to survey c.v.) sum of squares of the differences between the model value and the survey estimates of pup production.

The Working Group noted that the inclusion of a full age structure into the model was an improvement from previously used estimation programs. However, this model uses biological parameters that are fixed rather than estimated during the runs. Therefore, the uncertainties associated with the estimates of population size and sustainable catch are underestimated. The present model also does not estimate M. Due to the lack of data on this parameter, the Working Group decided that the estimates be provided assuming different values during this assessment. The Working Group **recommended** the estimation of M be incorporated into the fitting procedure in future models.

The following parameters were used for the assessments of the Greenland Sea harp seals:

Pup mortality: $M_0 = 3M_{1+}$

Age at maturity ogive:

Table 1 Estimates of proportions of mature females (p) at ages 3-15. From Frie *et al*. (in press).

Age	3	4	5	6	7	8	9	10	11	12	13	14	15
p	0.058	0.292	0.554	0.744	0.861	0.926	0.961	0.980	0.990	0.995	0.997	0.999	0.999

Pregnancy rate for mature females: F = 0.833

Natural mortality: M_{1+} = 0.10, 0.11, 0.12 .

Pup production estimates:

Table 2. Estimates of Greenland Sea harp seal pup production. From Øien and Øritsland (1995) and Haug *et al.* (this meeting, SEA-116).

Year	Estimate	c.v.
1983	58 539	.104
1984	103 250	.147
1985	111 084	.199
1987	49 970	.076
1988	58 697	.184
1989	110 614	.077
1990	55 625	.077
1991	67 271	.082
2002	98 099	0.204

The estimated populations are presented in Table 3.

Table 3. Estimated 2003 abundance of harp seals in the Greenland Sea.

Parameter	M_{1+}=0.10	M_{1+}=0.11	M_{1+}=0.12
1+ population in 2003	506 500	421 600	348 800
95% C.I. on 1+ population	464 131 – 548 869	386 000 – 457 000	318 841 – 378 759
Pup production in 2003	97 190	81 680	68 260
95% C.I. of pup production	89 135 – 105 239	74838 - 88 514	62468 – 74 052

The model predictions of pup production are shown in Figure 1.

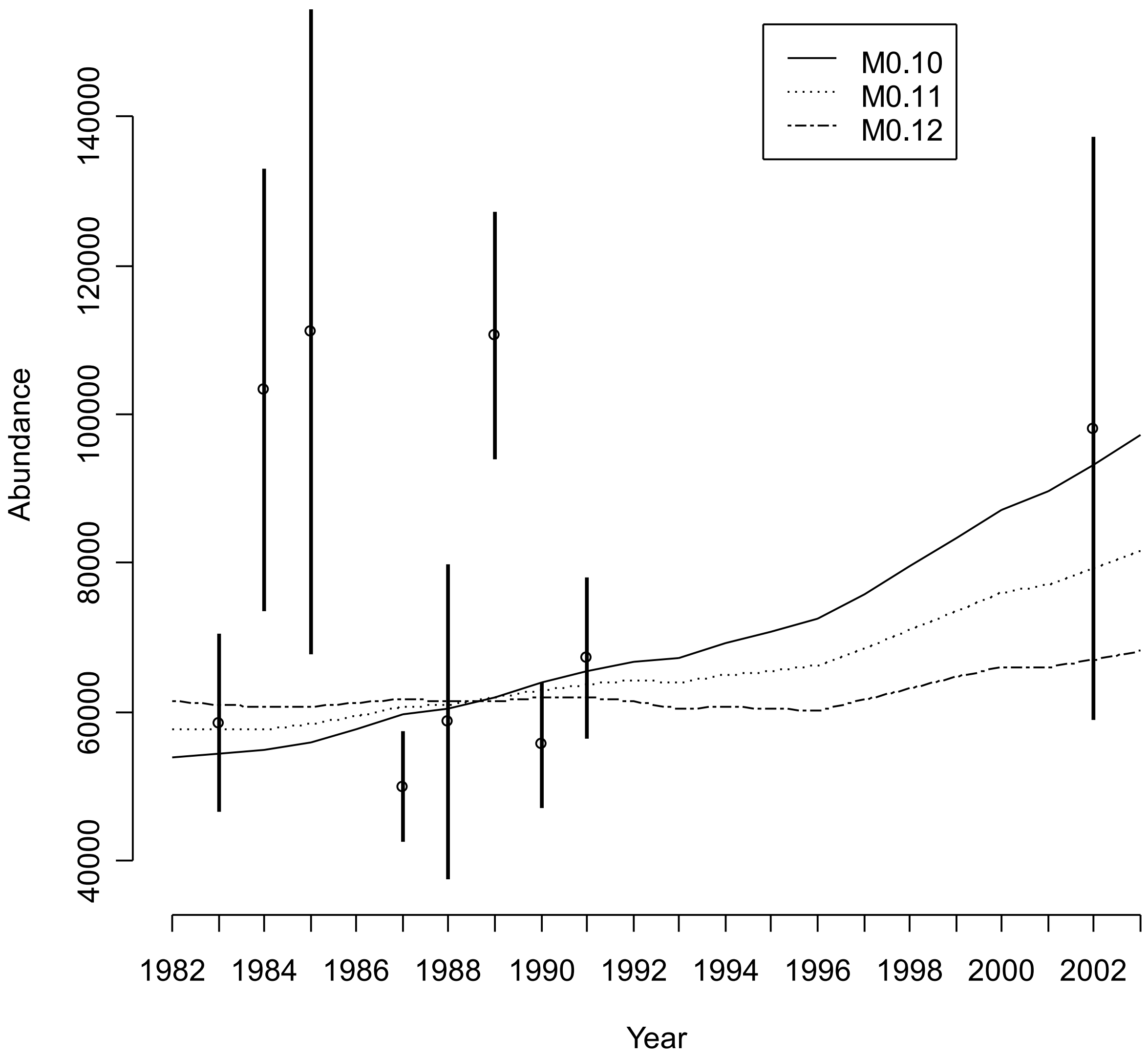

Figure 1 Plot of abundance estimates with 95% confidence limits and model projections fitted to these estimates under different assumptions of M_{1+} mortality for Greenland Sea harp seals.

This model estimates a lower population size than the previous model for $M_{1+} = 0.12$. Comparing the estimated mean birth rate of 1+ animals (f_1) calculated from the age structure and reproductive rates used in this model (0.39) to that estimated by the previous model (0.50) indicates that the overall reproductive rates are lower.

4.2.5 Catch options

Options are given for three different catch scenarios:

1. Current catch level (average of the catches in the period 1999 – 2003)
2. Sustainable catches.
3. Two times the sustainable catches.

The sustainable catches are defined as the (fixed) annual catches that stabilise the future 1+ population. These are calculated under the assumptions that the ratio M_0/M_{1+} is 3 (or 5 for White Sea/Barents Sea harp seals). The catch options are further expanded using different proportions of pups and 1+ animals in the catches.

As a measure of the future development of the estimated population, the following quantity is used:

$$D_{1+} = \frac{N_{2013,1+}}{N_{2003,1+}}.$$

Table 4 Catch options with corresponding population trend (D_{1+}) for the next 10-year period for harp seals in the Greenland Sea assuming $M_{1+} = 0.10$, 0.11 and 0.12

Option #	Catch level	Proportion of 1+ in catches	Pup catch	1+ catch	D_{1+}		
$M_{1+} = 0.10$					Lower CI	point	Upper CI
1	Current	48% (current level)	1953	1819	1.50	1.50	1.50
2	Sustainable	48%	18070	16680	0.98	1.03	1.07
3	Sustainable	100%	0	25150	1.01	1.05	1.09
4	2 X sust.	48%	36140	33360	0.40	0.48	0.58
5	2 X sust.	100%	0	50300	0.46	0.54	0.63
$M_{1+} = 0.11$							
1	Current	48% (current level)	1953	1819	1.32	1.32	1.33
2	Sustainable	48%	11138	10282	0.99	1.02	1.05
3	Sustainable	100%	0	15370	1.01	1.03	1.07
4	2 X sust.	48%	22276	20564	0.58	0.65	0.71
5	2 X sust.	100%	0	30740	0.62	0.68	0.74
$M_{1+} = 0.12$							
1	Current	48% (current level)	1953	1819	1.16	1.16	1.17
2	Sustainable	48%	5990	5530	0.99	1.01	1.03
3	Sustainable	100%	0	8200	1.00	1.02	1.04
4	2 X sust.	48%	11981	11059	0.75	0.79	0.83
5	2 X sust.	100%	0	16400	0.77	0.81	0.84

The Working Group presented catch options under three assumptions of mortality. However, they agreed that the preferred options are those assuming $M_{1+} = 0.12$. This was considered to be the most appropriate as it is the value estimated by the previous model and the current model seriously underestimates the uncertainty associated with the population size. Therefore, it is important to be cautious.

Under the estimates obtained assuming $M_{1+} = 0.12$, the current catch level (Options 1) will likely result in an increase in population size ($D_{1+}>1$. The sustainable catches (Options 2 and 3) are less than estimated previously due to the lower population size and reproductive rates. Catches 2X sustainable levels will result in the population declining by approximately 20 -25% in the next 10 years.

4.3 The White Sea and Barents Sea Stocks

4.3.1 Information on recent catches and regulatory measures

Recent Russian and Norwegian catches of harp seals in the White and Barents Sea are listed in Appendix IV, Table 5. The combined catches were 44,316 (including 40,555 pups), 36,535 (34,598 pups) and 43,234 (40,279 pups) in 2001, 2002 and 2003, respectively. This is 31-39% of the recommended sustainable yields (53,000 1+ seals, where 2.5 pups equaled one 1+ animal).

Few animals were caught in Norwegian gill net fisheries in 2001 and 2002 (Appendix IV, Table 6).

Svetochev and Golikov (this meeting, SEA-129) provide a history of Russian catches in the White Sea from 1920 – 2002.

4.3.2 Current research

Norwegian researchers collected data on age composition of 1+ seals during the commercial sealing on the moulting grounds in the Barents Sea in 2002 Also, samples were collected for diet studies from seals caught incidentally by coastal gill net fisheries in northern Norway during late winter in 2003.

Information about Russian aerial surveys (using infra red, video and photographic equipment) carried out on the harp seal moulting ground in the White Sea and the Kanin Nos Peninsula area in 2001 and 2002 were presented by Chernook. In 2001, surveys of beaters and 1+ harp seals were carried out from 22-26 April at an altitude of 150-300 m. Transects were spaced 7-15 km apart. Old harps (Saddlers) were predominant among the adult seals although there were a smaller number of grey-spotted animals. Beaters were also easily recognized well from the aircraft. Dense concentrations were observed. Adults and beaters occurred mainly in separate groups, but some mixed groups occurred. Generally, beaters were found at the ice edge and occurred in small groups (usually 2 to 6 individuals) while adults occurred in numerous small groups (2 to 9 animals) or in groups up to 30 individuals. Using methods similar to those used for estimating pup production, the number of moulting seals on ice in 2001 was estimated to be 805 379 + 86 083 1+ seals and 136 230+16 049 beaters. However, additional seals were observed in the water and moulting grounds north and east of the Kanin Peninsula were not surveyed. Therefore, this estimate underestimated the abundance of moulting seals.

Nilssen and Chernook presented preliminary results of a joint Norwegian/Russian airborne survey aimed to study potential overlap of distribution between harp seal and capelin in the northern Barents Sea (Zabavnikov *et al.*2003). This study was based upon aerial surveys in September and October 2002.

4.3.3 Biological parameters

Using reproductive data for the White Sea/Barents Sea stock previously published by Kjellqwist *et al*. (1995) and Timoshenko (1995), Frie *et al*. (2003) calculated mean age at maturity from age-specific proportions mature (referred to as MAM_{PMAT}) by a method analogous to that used for the Greenland Sea population (Frie *et al.* 2003). This method is different from the method of back calculation underlying the estimates (referred to as MAM_{BACK}) given by Kjellqwist *et al*. (1995). The Russian data set included samples from 1962-1964 and 1988, while the Norwegian data set included pooled samples from 1963-1971, 1976-1985 and 1990-1993. The individual estimates of MAM_{PMAT} for these samples were 5.3 yrs, 5.7 yrs, 6.6 yrs, 7.7 yrs and 8.5 years for the years 1962-1964, 1963-1971, 1976-1985, 1988 and 1990-1993, respectively. A sequential testing procedure split the time series into 3 periods with significantly different values of MAM_{PMAT} increasing from 5.4 years in 1962-1971 to 6.6 years in 1976-1985 and to 8.2 years in 1988-1993.

The values of MAM_{PMAT} calculated from the Norwegian samples for the sampling periods 1963-71 and 1976-85 were very close to the corresponding values of MAM_{BACK} calculated by Kjellqwist *et al.* (1995) (5.5 yrs, 6.7 yrs respectively) while the value of MAM_{BACK} for 1990-1993 was somewhat lower (8.1 yrs) than the corresponding value of MAM_{PMAT}. Frie *et al*. (2003) found a strong correlation between age at capture and the estimated age at first ovulation, which may be expected to introduce a strong correlation between age distribution of the sample and MAM_{BACK}. This was also confirmed by a resampling experiment showing significant differences between the age vector of the earliest and the later two samples, when applied to the different matrices of age specific probability of first-time ovulation in the three samples. A similar experiment showed no impact of age distribution of the sample on MAM_{PMAT}. Based on these findings Frie *et al*. (2003) recommended the use of MAM_{PMAT} in future studies although it was recognized that this method is also subject to potential sampling biases due to segregation of reproductive classes during moulting.

4.3.4 Population assessment

Pup production

Chernook and Kuznetsov (this meeting, SEA-123) surveyed the harp seal whelping patches in the White Sea in 2002. Prior to the survey, weekly satellite monitoring of ice conditions in the area were carried out. A reconnaissance flight conducted on 13 March 2002 indicated that whelping was practically finished at that time. The helicopter-based pup harvest was also finished at this time.

Two aerial strip transect surveys were then conducted on the 14 and 20 March 2002, each of which completely surveyed all whelping patches. The protocols of the surveys using video cameras (visual and IR ranges) are described in SEA-123. Pup production was estimated as 330,000 pups (SE = 34,000) from the survey observations using the methods of Kingsley *et al*. (1985). Pup production estimated using a modified method developed by Chelintsev (this meeting, SEA-124) resulted in an estimate of 334,000 (SE = 36,000) pups born.

Chernook (this meeting, SEA-122) described preliminary results of the 2003 aerial survey. Differences observed between the 2003 surveys and surveys conducted in 1998-2002 were:

- The main part of the ice mass under the influence of stable west wind was driven to the Mezen bay. Most parts of the White Sea were ice free.
- The densest part of the whelping patch moved 200-250 km to the north-east of the traditional area.

Surveys in 2003 were conducted on 18 and 21 March using standard aerial survey protocols. The mean estimate of pup production using the methods presented in Kingsley *et al*. (1985) based on the data from these two surveys was 293,000 pups (SE =53,000). Total pup production, including a landed catch of 35,000 pups, was 328,000. The Working Group agreed that although these estimates were preliminary, it would be useful to compare these results to the model estimates.

Chernook reviewed the series of White Sea harp seal pup surveys conducted since 1998 (Table 5). During the period 1998-2003, aerial surveys have been used in 8 surveys at the whelping patches. All these aerial surveys were conducted using the same technologies, platform, and staff. His experience suggests that:

1. Aerial surveys should be based upon multiple sensors rather than visual observations
2. A research survey should be conducted over a brief (1-2 day) period to minimize the effect of ice drift.
3. The optimal period to estimate pup production is mid March. Whelping practically ceases by 14 March and after 21 March gray pups appear.
4. When assessing seal pups it is necessary to account for all sources of error: seal identification in photographs, accuracy in determining the rookery boundary, ice drift, instrument error, navigation, weather conditions and others.

Chernook felt that the research air surveys for harp seals in the White Sea should be carried out annually. However, the surveys need additional control areas with in-situ observations of the biological characteristics of seals.

Table 5 Summary of PINRO photographic survey estimates of pup production in the White Sea

Year	Date of survey	Estimate of survey	Whelping %	Estimate incl. whelping	Correction rate	Estimate incl. corr.	Catch	Production no corr.	Production incl. corr.
1998	7. March	202	85	238	1.34	319	8	246	327
	12. March	290	99	293	1.34	393	13	306	406
	16. March	259	100	259	1.34	348	13	272	361
							Average	275	365
2000	18. March	309	100	309	1.08	334	31	340	365
2002	14. March	278	100	278	1.22	339	24	302	363
	20. March	306	100	306	0.98	300	24	330	324
							Average	316	344

Note: 1. This table is based upon estimates reviewed by WGHARP in 1998, 2000 and 2003
2. In 1998 the survey method including IR and B&W photos; the correction factor is based upon test ice data
3. 2000, 2002 – IR + video, correction on narrow angle camera (6 degree)

Finally, Kuznetsov briefly reviewed the algorithm used by PINRO to extrapolate strip transect observations (Chelintsev this meeting, SEA-124). This algorithm provides an alternative to the Kingsley *et al*. (1985) algorithm historically used by PINRO to extrapolate strip transect surveys for pups. Formulae used for estimating the number of animals and the statistical error are given. The algorithm provides adequate values for statistical error.

Population Estimates

Historical data on harvest and aerial photographic survey data in the period 1920-2003 were presented (Svetochev and Golikov, this meeting, SEA-129). It is suggested that the minimal production of pups (140 000) in this period could have been in 1963 due to large catches in the years before. However, there are large uncertainties in the data and any trends that may be inferred are unreliable.

Korzhev briefly discussed research at PINRO to further model the dynamics of the harp seal population abundance (this meeting, SEA 126). This research follows the work of Skaug and Øien presented at the recent workshop on improving methods of providing advice (ICES 2003). Their work, as part of WGHARP, developed the previous model of harp seal population abundance dynamics used by the Working Group. Korzhev's current research is designed to decrease the number of tuned parameters for estimating natural mortality, female age of sexual maturity, and female age of senesence. The model developed here (this meeting, SEA-126) is different from the model presented by Skaug and Øien (ICES 2003) mainly by the way in which the mean age of maturity is assessed. Development of the new model is continuing.

Using the model described by Bøthun *et al*. (this meeting, SEA-132) for the White Sea / Barents Sea harp seals, the current status of the stock was assessed. The following parameters were used:

Natural mortality: M_{1+} = 0.09, 0.10 and 0.11.

Pup mortality: $M_0 = 3M_{1+}$ (fixed) and $M_0 = 5M_{1+}$ (fixed; ICES CM Doc 1999/ACFM:7).

Age-at-maturity ogive:

Table 6 Estimates of proportions of mature females (p) at ages 5-11. From Kjellqwist *et al*. (1995)

Age	5	6	7	8	9	10	11
p	0.1	0.18	0.35	0.6	0.7	0.94	1.0

Pregnancy rate: f = 0.84 (Kjellqwist *et al*. 1995).

Pup production estimates:

Table 7 Estimates of Barents Sea / White Sea harp seal pup production (ICES CM 2001/ACFM:8; Potelov *et al*. 2003; Chernook *et al*. this meeting, SEA-123).

Year	Point estimate	c.v.
1998	286 260	.073
2000	322 474	.089
2000	339 710	.095
2002	330 000	.20

The Working Group noted that the first of these estimates of pup production are uncorrected, but that the later ones have corrections applied. The methods used to apply these corrections should be clarified and reviewed by the Working Group at the next meeting. Therefore the model was fit to data under two different assumptions about the ratio M_0/M_{1+}:

The estimated populations are presented in Table 8.

Table 8 Estimated 2003 abundance of harp seals in the Barents Sea / White Sea.

	$M_0 = 3M_{1+}$			$M_0 = 5M_{1+}$		
Parameter	M = 0.09	M = 0.10	M = 0.11	M = 0.09	M = 0.10	M = 0.11
1+ population in 2003	2 058 000	1 961 000	1 867 000	1 829 000	1,720,000	1 616 000
95% C.I. on 1+ population	1 857 551 - 2 258 449	1 769 992 – 2 152 008	1 685 079- 2 048 921	1 651 334- 2 006 666	1552894- 1887106	1 459 092 – 1 772 908
Pup production in 2003	341 900	328 900	316 100	329 600	315,600	301 600
95% C.I. of pup production	310 348 – 373 472	298 540 – 359 260	286 921 – 345 298	299 189 – 360 011	286 436 – 344 683	273 955 – 329 705

The model predictions of pup production assuming $M_0 = 3M_{1+}$ are shown in Figure 2

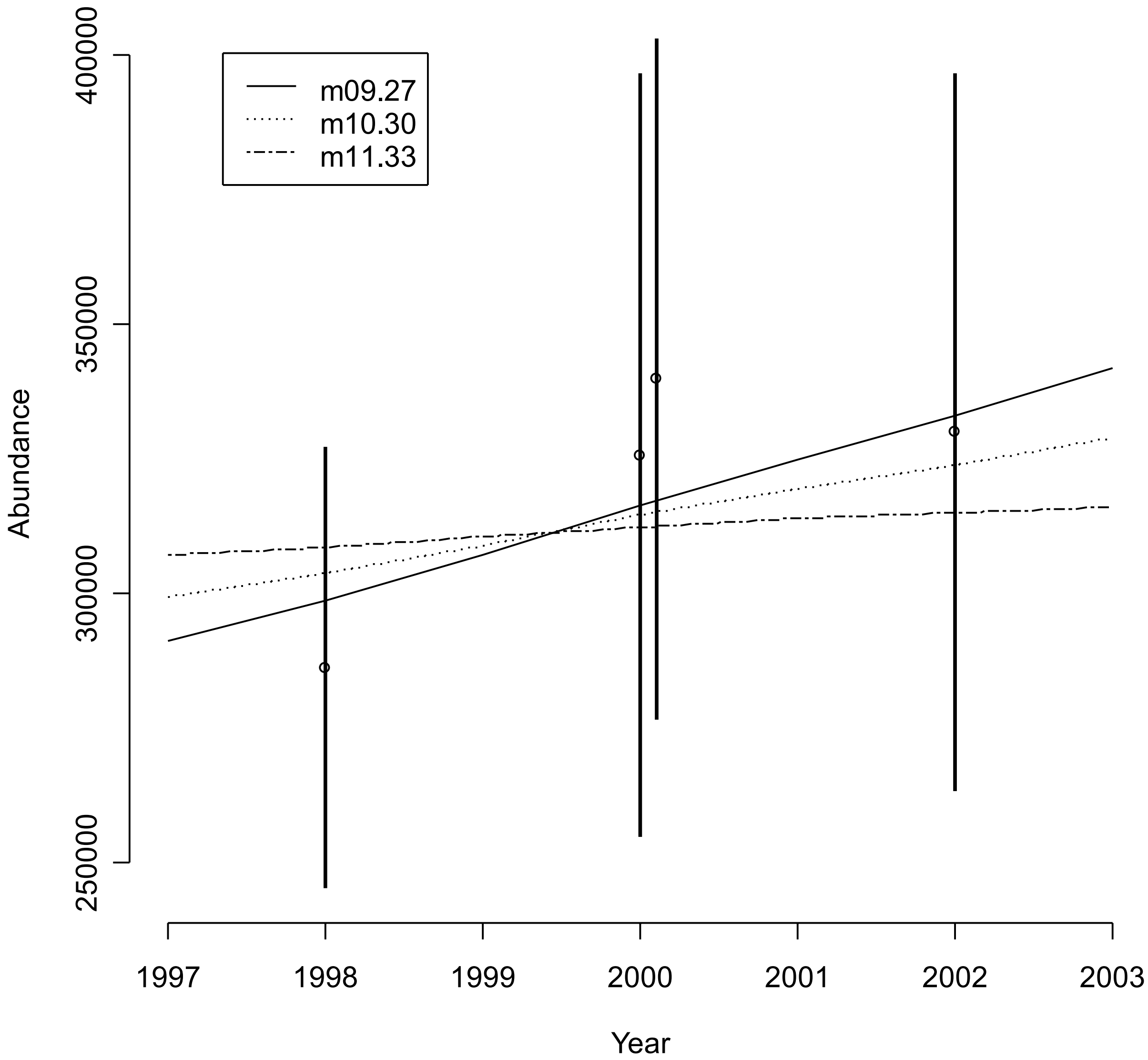

Figure 2 Modelled pup production ($M_0/M_{1+}=3$) for different mortality values (M_{1+}) and 95% confidence intervals (vertical lines) for the pup production estimates for White Sea/Barents Sea harp seals.

The model predictions of pup production assuming $M_0 = 5M_{1+}$ are shown in Fig. 3.

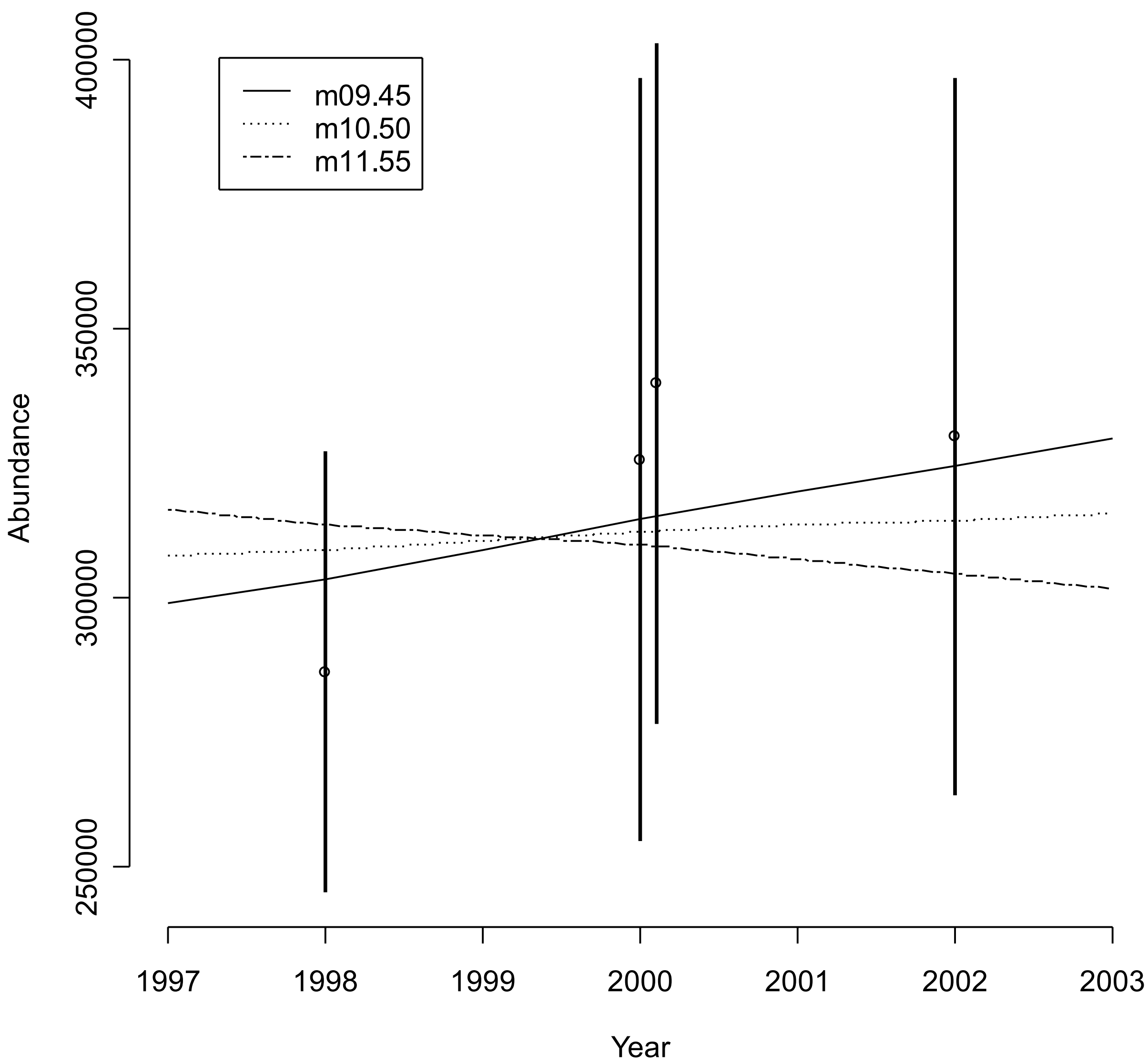

Figure 3 Modelled pup production ($M_0/M_{1+}=5$) for different mortality values (M_{1+}) and 95% confidence intervals (vertical lines) for the pup production estimates for White Sea/Barents Sea harp seals.

The model used in the previous assessment estimated M to equal 0.10 for the assumption of $M_0 = 3M_{1+}$ and 0.09 for the assumption of $M_0 = 5M_{1+}$. The current estimated 1+ populations for year 2003 are slightly higher than those estimated in the 2000 assessment for the same assumptions, but the differences are not significant. However, the estimated mean birth rate of 1+ females was estimated to be lower indicating a lower reproductive rate for the population than previously estimated. Also, given that the ratio M_0/ M_{1+} and the birth rate (f) has been fixed (and hence the uncertainty about these parameters has been ignored), the uncertainty about the other parameters will be underestimated.

The Working Group noted that the estimates of 2003 pup production provided by the model were similar to the preliminary survey estimates provided by Chernook *et al.* (this meeting, SEA-122)

4.3.5 Catch options

Catch options are given for current catch levels, sustainable yield and double the sustainable yield level under differing assumptions of M and the relationship between M_o and M_{1+}.

Table 9 Catch options with corresponding population trend (D_{1+}) for the next 10-year period for harp seals in the White Sea / Barents Sea assumming M = 0.09, 0.10 and 0.11 and M_o = $3M_{1+}$.

Option #	Catch level	Proportion of 1+ in catches	Pup catch	1+ catch	D_{1+}		
M_{1+} = 0.09					Lower CI	Point	Upper CI
1	Current	7% (current level)	37979	2992	1.29	1.30	1.31
2	Sustainable	7%	152 706	11 494	0.93	0.98	1.02
3	Sustainable	100%	0	75 500	1.01	1.05	1.08
4	2 X sust.	7%	305 412	22 988	0.45	0.53	0.62
5	2 X sust.	100%	0	151 000	0.62	0.69	0.76
M_{1+} = 0.10							
1	Current	7% (current level)	37 979	2992	1.03	1.05	1.07
2	Sustainable	7%	97 743	7 357	0.96	0.99	1.01
3	Sustainable	100%	0	47 500	1.01	1.03	1.05
4	2 X sust.	7%	195 486	14 714	0.66	0.71	0.77
5	2 X sust.	100%	0	95 000	0.77	0.81	0.85
M_{1+} = 0.11							
1	Current	7% (current level)	37979	2992	1.01	1.02	1.03
2	Sustainable	7%	46 686	3 514	0.99	1.00	1.01
3	Sustainable	100%	0	22 380	1.01	1.02	1.03
4	2 X sust.	7%	93 372	7 028	0.84	0.87	0.89
5	2 X sust.	100%	0	44 760	0.89	0.91	0.93

Table 10 Catch options with corresponding population trend (D_{1+}) for the next 10-year period for harp seals in the White Sea / Barents Sea assuming M = 0.09, 0.10 and 0.11 and M_o = $5M_{1+}$.

Option #	Catch level	Proportion of 1+ in catches	Pup catch	1+ catch	D_{1+}		
M_{1+} = 0.09					Lower CI	Point	Upper CI
1	Current	7% (current level)	37979	2992	1.15	1.16	1.17
2	Sustainable	7%	102 486	7 714	0.96	0.99	1.01
3	Sustainable	100%	0	45 100	1.01	1.03	1.05
4	2 X sust.	7%	204 972	15 428	0.65	0.71	0.76
5	2 X sust.	100%	0	90 200	0.76	0.80	0.85
M_{1+} = 0.10							
1	Current	7% (current level)	37979	2992	1.01	1.02	1.03
2	Sustainable	7%	45198	3402	0.99	1.00	1.01
3	Sustainable	100%	0	19350	1.01	1.02	1.03
4	2 X sust.	7%	90396	6804	0.86	0.88	0.90
5	2 X sust.	100%	0	38700	0.90	0.92	0.94
M_{1+} = 0.11							
1	Current	7% (current level)	37 979	2 992	0.88	0.89	0.90
2	Sustainable	7%	1 302	98	1.00	1.00	1.00
3	Sustainable	100%	0	900	1.00	1.00	1.00
4	2 X sust.	7%	2 604	196	0.99	0.99	0.99
5	2 X sust.	100%	0	1800	0.99	0.99	0.99

Current estimates of sustainable catches levels lower than those obtained during the previous assessment when using the same assumptions of mortality. The decline is greatest in the model assuming $M_o = 3M_{1+}$. These differences are likely due to the higher reproductive rates used in the previous estimate.

The Working Group felt that it was difficult to decide between the model runs given the lack of information on mortality rates. However, considering the previous model estimated M to be 0.10 for the assumption of $M_o = 3M_{1+}$ and 0.09 for the assumption of $M_o = 5M_{1+}$, it felt that these were the preferred choices. It was noted that sustainable catches were similar under these two assumptions.

4.4 The Northwest Atlantic Stock

4.4.1 Information on recent catches and regulatory measures

Current catches of harp seals in Canadian waters are presented in Appendix IV, Table 10 and Stenson (this meeting, SEA-118). The preliminary estimates for 2000 reported at the previous meeting of the working group (ICES CM 2001/ACFM:8) were not changed. After a low catch in 2000 due to poor weather, low market prices and increased costs, the harvest increased in 2001 to over 226,000. In 2002 high pelt prices (>$60 Can / pelt) resulted in increased effort and catches (312,000) that exceeded the total allowable catch (275,000). Harvests remained high in 2003 although the quota was not reached. As in the past, the vast majority of the harvest was directed towards young of the year. The proportion of pups in the commercial harvest rose from 92.8% in 2000 to 96.8% in 2003. Although some raggedy-jackets were taken, most of the catch consisted of beaters.

The total allowable catch for harp seals remained at 275,000 between 2000 and 2002. In 2003, however, a three year management plan was implemented. The objective of this plan is to maximize the economic return to sealers during a period of high pelt prices while maintaining the population above a precautionary reference level of 3.85 million (Hammill and Stenson 2003a). The plan allows for a total harvest of 975,000 over three years with a maximum of 350,000 in any one year.

Rosing-Asvid provided an update on recent catches of Northwest Atlantic harp seals in Greenland waters (Appendix IV, Table 9a). There is no quota for harp seals in Greenland. Catches increased steadily from ~15,000 in the 1980s up to ~100,000 in 2000. However, in 2001 catches declined ~20% to ~79,000. The increase in catches was highest among adult seals because of more adults coming into Greenland waters. The decrease is mostly among adults seals which appear to be less abundant in inshore waters.

4.4.2 Current research

Stenson presented information on current research on NW Atlantic harp seals by Canadian scientists in Newfoundland. They have maintained their biological sampling program to monitor the age structure of the harvest and to collected information on condition, diet and reproduction. They have also continued their studies on distribution and seal/fisheries interactions. Modelling studies to determine the impact of the new management approaches adopted by Canada in 2003 are described in Hammill and Stenson (2003b).

Hammill reported on research being carried out in the Gulf of St. Lawrence. This research is focusing on studies of growth and condition of seals on the whelping patch and the use of fatty acids and/or stable isotopes to provide additional information on the diet of harp seals.

The Canadian government has recently approved funding for two-year study on the impact of seals on the recovery of Atlantic cod (*Gadus morhua*) in Canadian waters. This program will focus on harp, hood and grey seals. Included in this program are a harp seal pup production survey (scheduled for March 2004), satellite tracking studies to determine movements and diving behaviour, expanded collections of diet data from seals in offshore areas and a pilot study of the feasibility of reducing the number of seals present in a fjord area of Newfoundland where large amounts of cod are known to winter.

Rosing-Asvid described current research in Greenland. Greenland scientists are continuing their study of the growth, condition, reproduction and diet of harp seals in West Greenland.

4.4.3 Biological parameters

No new information on biological parameters of NW Atlantic harp seals was presented.

4.4.4 Information on the state of the stock

Hammill and Stenson (2003b) present the results of model runs designed to explore the impact of various harvest scenarios. Up until 2003, the Northwest Atlantic harp seal stock management objective was to maintain the population at a constant level. The quota was set at 275,000. In 2003, a new management approach was implemented. This approach established a Precautionary Approach framework involving precautionary reference points established at 70% and 50% of the estimated maximum population size of 5.5 million animals. A lower limit reference point was set at 30% of the estimated maximum population size. Management requested that science examine the impact of various 3 year harvest scenarios, ranging from annual harvests of 255,000 to 500,000 animals on the population. A new management objective allowing a maximum economic benefit to be obtained while maintaining a population size greater than the precautionary reference point of 70% of maximum population observed was adopted. The replacement yield was estimated to be 255,000; therefore all harvests greater than this level will result in a decline in the population. Of the various scenarios, management adopted a harvest of 975,000 animals to be taken over 3 years, with harvests not to exceed 350,000 in any single year. Harvest simulations were examined assuming that Greenland and Canadian catches, by-catch levels and struck and loss correction factors did not change over the period of the projections. It was also assumed that no unusual ice years resulting in unusual mortality events would occur over the period of the projections. Using the point at which the lower 60% C.I. crosses the precautionary reference point, N_{70}, the population would decline but will remain above the precautionary level in the short term. However, the population is predicted to decline to the reference level by about 2011 assuming that the entire quota of 975,000 was taken and that harvests returned to 275,000 after the 3 y period.

5 Hooded SEALS (cystophora cristata)

5.1 Stock Identity, Distribution and Migration

There are no new data on hooded seal stock identify, distribution or migration from either Norway or Canada. However, Canada expects to begin a stock structure study for hooded seals basin-wide once an appropriate student is found.

Russian researchers (PINRO) have found few hooded seals in the Kara Sea.

5.2 The Greenland Sea Stock

5.2.1 Information on recent catches and regulatory measures

Catches of Greenland Sea hooded seals during 2001-2003 (Appendix IV, Table 1) remained well below the estimated sustainable yields (10,300 1+ animals). Thus, only 27-49% of the given quotas were fulfilled. Total catches (all taken by Norway, Russian sealers did not operate in the Greenland Sea in the period) were 3,820 (including 3,129 pups), 7,191 (6,456 pups) and 5,283 (5,206 pups) animals in 2001, 2002 and 2003, respectively. Parts of, or the whole quota, could be taken as weaned pups assuming 1.5 pups equalled one 1+ animal.

5.2.2 Current research

Ecological studies of harp and hooded seals have been conducted by Norway in the Greenland Sea in 1999 (September-October), 2000 (July), 2001 (February), and 2002 (September-October). Samples were collected throughout the year (summer, fall, winter) to estimate body condition and diet composition using stomach contents, fatty acid and stable isotope analysis. Preliminary results are given in Haug *et al*. (2002). Samples were also collected for use in a study of stock structure being carried out by Canadian scientists.

5.2.3 Biological parameters

There are no new data from Russia or Norway.

5.2.4 Population assessment

Pup production

In 2002, Norway planned to survey both harp and hooded seals, but they found it impossible to survey both satisfactorily. So, priority was given to harp seals. As such, 1997 remains the only abundance estimate for this stock. If funds become available, Norway will do a hooded seal survey in 2005 jointly with Canada so that both the Greenland Sea and NW Atlantic stocks are surveyed simultaneously.

Population Estimates

Estimates of pup production and total population were obtained using the model described in Section 4.2.4 (Bothun *et al*, this meeting, SEA-132).

The following parameters were used for the assessments of the Greenland Sea hooded seals:

Pup mortality: $M_0 = 3M_{1+}$

Age at maturity ogive:

Table 11 Estimated proportion of mature females (p) at ages 2-10, based upon data obtained from the NW Atlantic population (Stenson unpublished data)

Age	2	3	4	5	6	7	8	9	10
P	0.029	0.262	0.504	0.734	0.802	0.802	0.850	0.908	1.00

Pregnancy rate for mature females: F=0.97

Natural mortality: M_{1+} = 0.10, 0.11, 0.12.

Pup production estimates: Estimate of 23,762 pups 95% C.I. 14,819 – 32,705 in 1997 (ICES CM 2001/ACFM:8).

The estimated populations are presented in Table 12.

Table 12 Estimated 2003 abundance of hooded seals in the Greenland Sea.

Parameter	$M_{1+} = 0.10$	$M_{1+} = 0.11$	$M_{1+} = 0.12$
1+ population in 2003	142 700	131 500	120 400
95% C.I. on 1+ population	80 380 – 205 020	73 250 – 189 749	65 465 – 175 335
Pup production in 2003	33 250	30 950	28 660
95% C.I. of pup production	19 371 - 47 083	18012 - 43 830	16 747 – 40 801

The model predictions of pup production are shown in Figure 4.

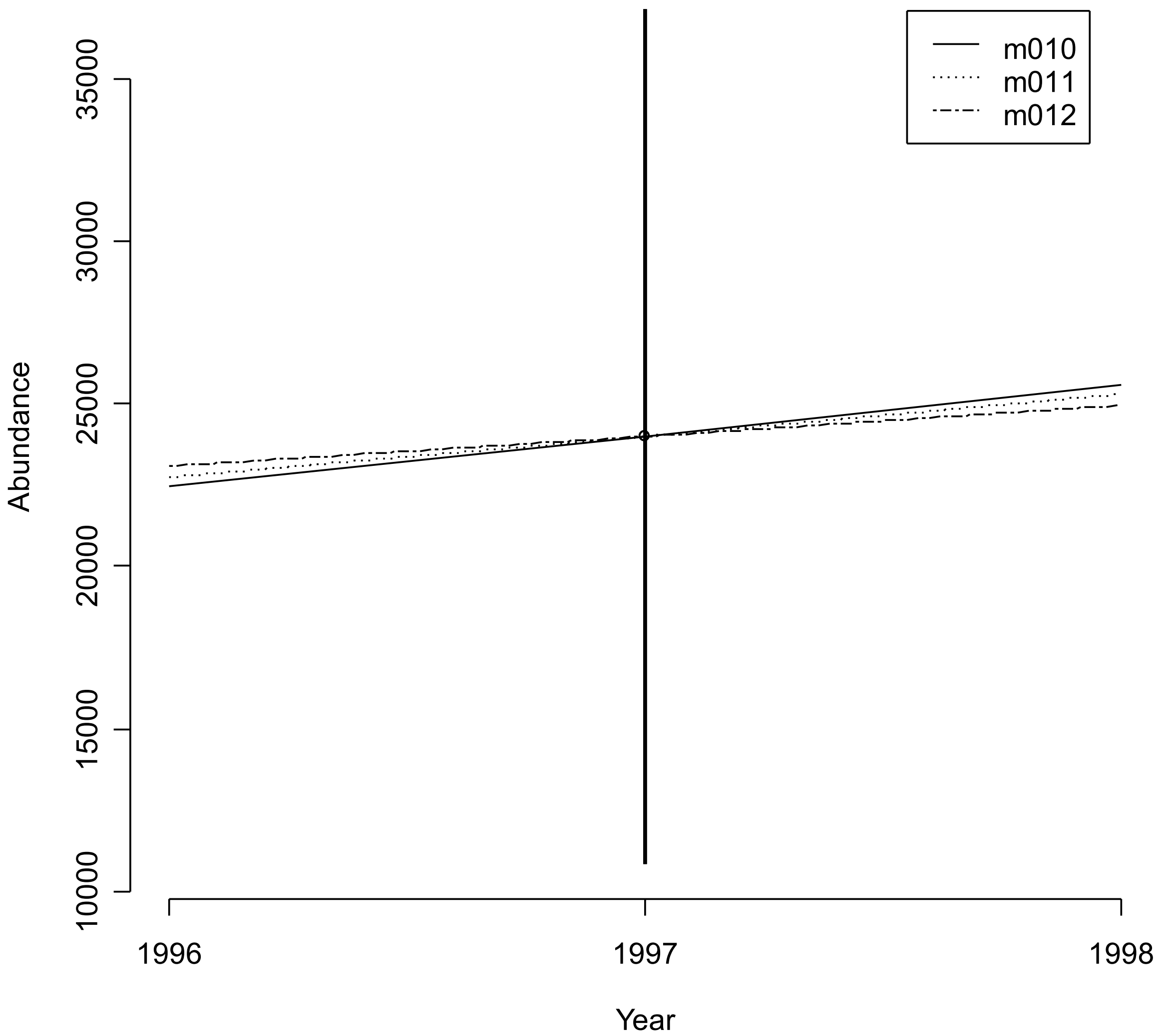

Figure 4 Model estimates of pup production assuming different levels of mortality (M_{1+}) fitted to the 1997 pup production estimate (95% confidence interval shown by vertical line) for Greenland Sea hooded seals.

The model estimates of 1+ and pup production obtained from this model are similar or slightly higher than those obtained using the previous model (1+ 102,000 CI 57,000 – 147,000; pups 28,100 CI 16,000-40,000). However, the estimated mean birth rate for 1+ females is lower than used previously (0.48 vs. 0.66). The confidence intervals are wide, reflecting the fact that the model has difficulty estimating abundance with only a single pup production estimates for the fitting procedure.

5.2.5 Catch options

The Working Group was very concerned about the risk of providing quota advice given the limited amount of information available. The single estimate of pup production is over 6 years old and there are no estimates of reproductive rates for this stock. Therefore, they agreed that any advice provided should be extremely cautious. One method of providing advice in such data poor situations is through the use of the Potential Biological Removals (PBR) approach (Hammill and Stenson 2003a).

The Potential Biological Removal (PBR) has been defined as:

$$PBR=0.5 \cdot R_{Max} \cdot Fr \cdot N_{Min},$$

where R_{Max} is the maximum rate of increase for the population , F_r is a recovery factor with values between 0.1 and 1 and N_{Min} is the estimated population size using 20th percentile of the log-normal distribution (Wade and Angliss 1997; Wade 1998). R_{Max} is set at a default of 0.12 for pinnipeds. The Working Group agreed that it was appropriate to set the recovery factor (F_r) 0.75 given the time since the last survey and uncertainty in parameters used to determine the total abundance.

The PBR approach can be used when only a single estimate of abundance is available. This approach would be appropriate within the precautionary approach to marine resource management implemented by NAFO/ICES. Moreover, the group recommends that if an additional survey is not conducted by 2005, the time of the next assessment, it will be unable to provide harvest advice for this stock.

Estimates of the PBR level of removals are:

Table 13 Estimated PBR removals for hooded seals in the Greenland Sea.

Parameter	$M_{1+} = 0.10$	$M_{1+} = 0.11$	$M_{1+} = 0.12$
N_{min}	149 200	137 444	125 467
PBR	6 714	6 185	5 646

The Working Group noted that M_{1+} was estimated to equal 0.12 by the previous model. Therefore, they recommend this option.

5.3 The Northwest Atlantic Stock

5.3.1 Information on recent catches and regulatory measures

Canadian catches of hooded seals (Appendix IV Table 11, Stenson this meeting SEA-118) remained low (14-151 over the last four years) and well below the Total Allowable Catch of 10,000. It is illegal to take "blue backs" in Canada and there are no markets for older hoods. There is a request from hunters to allow the hunting of blue backs which is being examined by the government. However, it has been stated that it is unlikely to change until there is another survey of hooded seal pup production.

Greenland catches have remained around 6,000 (range 5-10,000) in recent years (Appendix IV, Table 8). The majority of hooded seals are taken near the moulting area of East Greenland in July and in SW Greenland in August. There are currently no quotas on the number of seals taken.

5.3.2 Current research

There are no directed studies on hooded seals currently underway in Canada. However, they are included in the ongoing annual sampling program. As a result, biological data (age, growth, condition, reproduction and diet) have been collected from a small number of animals each year. These data will be analyzed once sufficient sample sizes are obtained.

Samples for a study of stock identity of hooded seals have been collected. Tissue samples from all four whelping areas (Greenland Sea, Gulf, Front and Davis Strait) are now available. Analyses will begin once the appropriate lab is identified.

The recently announced program designed to investigate the impact of seals on cod (see 4.3.2) will provide new opportunities for research on hooded seals in the Northwest Atlantic. It is anticipated that new studies on the abundance, diet, movements and diving behaviour will be initiated.

Sampling programs in Greenland do not encounter many hooded seals. However, biological data are obtained when they are available.

5.3.3 Biological parameters

At the last meeting (ICES CM 2001/ACFM:8), the Working Group suggested that all of the available morphometric data on hooded seals be gathered together and cooperatively analyzed. Analysis of the Canadian data is almost complete and a M.Sc. thesis has been submitted. Additional data from Greenland and the Denmark Strait moulting area have been provided and will be included in subsequent analyses.

5.3.4 Information on the state of the stock

No new information on the status of this stock was presented. This stock has not been surveyed since 1990. However, a pup production survey is scheduled for March 2005.

6 Biological reference points for North East Atlantic harp and hooded seals

ACFM has referred this issue to WGHARP which in turn convened a workshop on improving methods of providing advice (ICES 2003 as summarized in Section 3 of this report). The workshop concluded that the precautionary approach can be applied to seal populations. However, it identified the need to use abundance in terms of numbers rather than biomass or fishing mortality. The workshop did not define the different reference points applied to marine mammals and identified the need for such definitions. Once this is completed approaches to estimating the values of the reference points can be determined. The recommendations of the Workshop are presented in Section 3 of this report. Findings of this Workshop were supplemented by additional presentations at this meeting by Hammill and Filin which are summarized below.

Hammill gave a brief review of reference points and presented a discussion paper (Hammill and Stenson 2003a) on the application of the Precautionary Approach (PA) and conservation reference points to the management of Atlantic seals. Resource management usually involves a trade off between conservation, economic and political concerns in establishing harvest levels. Often, decisions fail to consider the uncertainty associated with the available information on the resource, with negative consequences. The Precautionary Approach (PA) brings scientists, resource managers and stakeholders together to identify clear management objectives, to establish specific benchmark or reference levels, to enable the status of the resource to be evaluated and to identify specific management actions that would be triggered when a population approaches or falls below the benchmark(s). Within this framework, Conservation, Precautionary and Target reference points can be identified and linked to specific actions to aid in managing the resource. The PA also recognizes that the amount of information available concerning the status of a resource may vary and that a lack of information is not sufficient to delay taking a management decision.

A key component of this approach is that at certain stages or levels of the population, specific management actions will be established, to aid managers in managing the resource. These levels can be referred to as Conservation, Precautionary and Target reference points. A conservation reference point is the value of a property of a resource that, if violated, is taken as direct evidence of a conservation concern. A conservation concern exists when there is an unacceptable risk of serious or irreversible harm to the resource and as such, conservation or limit reference points are provided as point estimates to be avoided with high probability. However, given that there is uncertainty in the data, model formulations and parameters used to estimate both the current status of a resource and the conservation reference point, conservation reference points should also be associated with Precautionary reference points. A Precautionary reference point is an indicator of the level of a resource at which harvesting or fishing levels must change in order to reduce the risk that the resource will decline. To avoid such a decline, management actions should increase the chance that the resource will attain or exceed the Precautionary reference point. The intent is that if there is a high probability of complying with the Precautionary reference point, then we are confident that the conservation or limit reference point will not be violated. Ideally, advice should be framed in terms of complying with precautionary reference points, rather than avoiding conservation (limit) reference points. Conservation and Precautionary reference points are intended to constrain removals within safe biological limits for both the target species and other components within the ecosystem. A third reference point, called the Target reference, is the level of the resource that the species should be kept at. Target reference points are identified by managers and stakeholders (with the assistance of scientists) and are intended to meet management objectives (ICES 2001). Within this context, fishery management strategies identify specific management actions, taking into account the uncertainties related to the status of the resource, which will maintain or restore populations to levels consistent with previously agreed target reference points.

Harp and hooded seals are commercially exploited to varying levels throughout the North Atlantic. The availability of scientific information concerning the status of these resources (abundance, reproductive and mortality rates) also varies between the species. A conceptual framework for applying the PA to Atlantic seal management was outlined (Figure 5). For a Data Rich species, two precautionary and a conservation reference level are proposed. A precautionary reference level could be established at 70% (N_{70}) of the pristine population size or a proxy of the pristine population (e.g. maximum population size). When populations fall below N_{70}, conservation objectives assume a greater role in the setting of harvest levels, and measures are put in place to allow the population to increase above the precautionary reference level. A second precautionary level is established at 50% of the estimated pristine population size, while a conservation limit resulting in closure of commercial harvesting is established at 30% of the estimated maximum population size.

Species with no recent population data are considered Data Poor and require a more risk adverse approach to their management. Data Poor in Canada occurs in populations with less than three abundance estimates, no recent abundance estimate within the last 5 years, and an absence of recent data on fecundity or mortality rates. In these situations, the uncertainty associated with the resource's status and the impact of a particular management action increases and as a result, more caution is required. This could be accomplished by identifying the maximum allowable removals that will ensure that the acceptable risk of the population falling below this reference point is only 5%. This level has been referred to as the Potential Biological Removal (PBR) and is easily calculated using default values and an estimate of abundance. Since the only data required is an estimate of population size, it or a similar approach is appropriate for data poor species. The PBR approach has the added advantage that the simulation trials used to establish the appropriate population size (N_{Min}) ensured that the formulation was robust when the model assumptions were relaxed and plausible uncertainties were included.

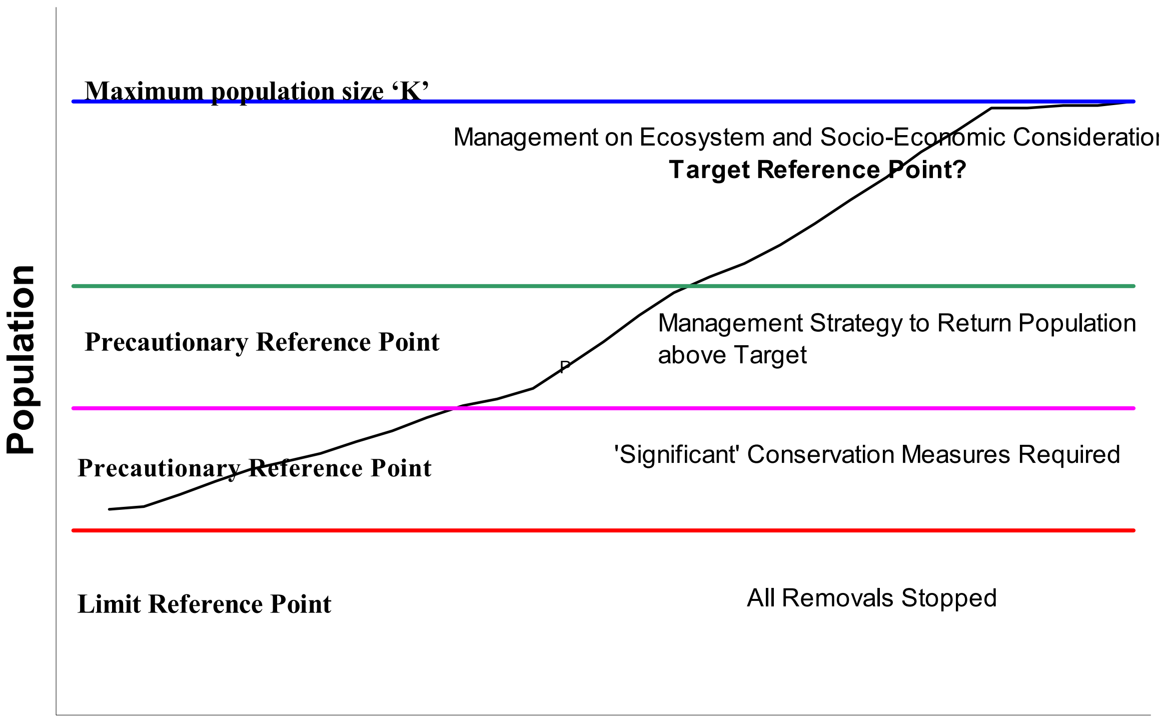

Figure 5 Reference points and control rules for implementing the Precautionary Approach into the management of harp and hooded seals in North Atlantic.

Filin (this meeting, WP-SEA 125) reviewed the use of the precautionary approach for fishing management. It requires that biological reference points be established for every exploited stock. ICES considers that the stock status and the level of its exploitation are within the safe biological limits if there is a high likelihood that the Spawning Stock Biomass (SSB) is higher than established limit reference point $\mathbf{B}_{lim}$ and fishing mortality (F) is lower than value $\mathbf{F}_{lim.}$ Because of uncertainties in estimations of spawning biomass and fishing mortality, management actions to increase the spawning stock biomass or decrease exploitation should be taken if precautionary biological reference points $\mathbf{B}_{pa}$ and $\mathbf{F}_{pa}$ are reached. $\mathbf{B}_{pa}$ and $\mathbf{F}_{pa}$ are established to provide a high probability that mature stock biomass will not reach $\mathbf{B}_{lim}$, and $\mathbf{F}_{lim}$. ICES considers $\mathbf{B}_{lim}$ as the size of spawning biomass, below which recruitment becomes impaired, i.e. probability of poor recruitment increased. Thus, $\mathbf{B}_{lim}$ is based on the idea that although a link between year-class abundance exists, however, it is not strict. This approach to the formulation of limit reference points can not be used in relation to the harp seals, since the concepts on which it is based are not applicable. The notion of year-class strength applied for fish is unacceptable for harp seals who exhibit a much more pronounced link between the abundance of brood stock and the recruitment of adult stock. For White Sea\Barents Sea harp seals Filin considers it very important to incorporate economic considerations when establishing Biological Reference Points. If the stock declines to too low a level, harvesting will no longer be profitable. This will lead to closure of the hunt, which will have important economic and social consequences. For this reason the following definition for a limit reference point for this stock was suggested: N_{lim} could be defined as the minimal number of mature females that are able to provide sufficient reproduction suitable for long-term profitable harvesting under an annual commercial withdrawal. An estimate of the minimal allowable catch could be based on the analysis of fishery statistics, which are the only reliable source of long-term information about the White Sea population. The number of females bearing pups may be determined from data obtained during aerial surveys for pup production regularly conducted in the White Sea. A value of Nlim could be calculated on the basis of an established minimal allowable catch using a population model and a management objective of maintaining a stable population (i.e. replacement harvesting).

The Working Group discussed these presentations and the Workshop recommendations and came to agreement on a number of points that will help define Biological Reference Points for harp and hooded seals:

1. There is a common management framework that can be applied to different stocks though reference points and control rules may be different for different stocks. As such, a hierarchy of reference points can be defined for different stocks (Fig. 5)

2. Abundance is the metric to be used in establishing the reference points, though other population metrics (e.g., condition) will be useful in establishing management response

3. The use of N_{MSY} and N_{LOSS} is inappropriate for marine mammals.

4. The carrying capacity of the environment ('K') is difficult to estimate for seals and therefore should not be used as an upper reference point for these populations

5. Some stocks will be considered data poor and will be managed under a different set of control rules. This argues for frequent (every 5 years or less), precise (CV < 30%) abundance surveys.

6. The method of assessing harp and hooded seals demands periodic estimates of pup production. Given the high proportion of pups in the current harvest, there will be a time lag between a harvest and when the effects of that harvest will be evident in the breeding population (owing to the delay between birth and sexual maturity), it is important to ensure that there are precautionary reference levels that allow for this time lag.

Numerous technical issues have yet to be resolved. These include:

1. How should the reference points be defined? For example, should N_{CRIT} be defined on a purely biological basis or are both biology and economics relevant?

2. How are data rich, poor and inadequate stocks defined and what rules should be applied for dealing with them?

3. What control rules are appropriate for the various states of the stocks?

The Working Group concluded that if ACFM accepts the general framework proposed, WGHARP will work through correspondence to develop a proposal defining the reference points to be discussed at the Working Group's next meeting.

7 Predation on commercially important fish species by harp and hooded seals-review of diet and consumption studies, with particular emphasis on methodology

The opening discussion in this session (Nilssen and Haug, this meeting, SEA-121) provided an overview of traditional methods for diet analysis, and some of the potential biases or sources of error. Examination of foraging ecology and predatory interactions of seals are important, in order to assess their role in marine ecosystems, and to quantify marine mammal– fishery interactions. Individual variability in seals foraging behaviour in relation to variability of the abundance and distribution of prey resources provides the basic data for analyses of prey consumption.

The difficulty of obtaining data on underwater feeding of harp and hooded seals through direct observations has made it necessary to use various indirect methods to estimate diets (see, e.g., Pierce & Boyle 1991; NAMMCO 2002; Barros & Clarke 2002). Studies of seal diets have traditionally been based on analyses of either stomach and intestinal contents or scat. Undigested specimens along with hard remains such as fish otoliths, cephalopod beaks and exoskeletons from crustaceans recovered from such samples are used to reconstruct and quantify the diet of marine mammals. New methods of diet analysis have emerged in the past decade such as fatty acid, stable isotope, genetic analyses and remote sensing (see Table 14).

In their review of methods used in studies of marine mammal diets, Barros and Clarke (2002) concluded that, although identifying and measuring items in vomit, scats, and gastrointestinal contents have several disadvantages and sources of errors, it provides more information at considerably less cost than other methods (such as fatty acid signatures, stable isotopes and genetics), and cannot be replaced effectively by any other method at present. A recent NAMMCO workshop, addressing questions relating to uncertainties in quantitative descriptions of marine mammal diets (NAMMCO 2002), came to the same conclusion. Such methods provide information on meal size and relative composition of prey, size classes of prey, small scale spatial and temporal distribution of diets and predator-prey dynamics. It is easy to obtain samples from harvests, bycatch, culling or strandings, and laboratory treatment of samples is simple. Studies combining various methods are preferable.

Studies attempting to assess prey consumption by populations of marine mammals should include consideration of individual variability in their study design and analysis. Corkeron (this meeting, SEA-117) provides a brief discussion of the need to consider this variability and points out relevant literature. He suggests that new analyses methods develop in the field of community ecology be explored.

Diet studies in Greenland were next reviewed (Rosing-Asvid, this meeting, SEA-119). These studies use traditional methods of analysis of seal stomachs and intestines based upon the presence of hard and undigested soft parts. Current work is focusing on assessing seasonal and spatial variations in harp seal diet. Rosing-Asvid also discussed how mean weight of the stomach contents and increases in blubber thickness might relate to the estimated rate of consumption in various areas.

Canadian researchers have examined diets reconstructed from harp and grey seal stomachs and intestines. Stable isotope analyses were also used to determine if reconstructed diets were similar between the three components (Hammill *et a*l, this meeting, SEA-120). Diet reconstructions in harp seals (n=18) using stomach and small intestine contents consisted of 88%-95% by weight or 71%-86% by energy of invertebrates, while large intestine contents suggested a diet of 10% (sd = 17.3) invertebrates by weight and 6.7% (sd = 2.0) by energy. Stable isotope ratios determined only for harp seals suggested their diet consisting of mostly invertebrates, indicating that diet reconstructions based on hard parts from stomachs are likely to be more representative than reconstructions from large intestine contents. Future studies should focus on the probability that ingested prey will be recovered in the faeces, rather than being concerned with the loss of individual otoliths.

Stenson provided a review of methods used to determine diet of seals in Canada. Wet weights are estimated from measurements of whole fish or hard parts (otoliths, beaks, etc.). However, hard parts are only used when they show little or no digestion. Specific protocols have been developed to identify how to estimate the size of prey when digestion has occurred. The choice of regression lines used to reconstruct original weights is critical, as different equations can provide significantly different results. The regressions used should be based on local prey and be derived from samples that cover the range of prey sizes found in the diet. There may be considerable uncertainty in the estimates obtained from regressions and this should be considered when estimating the total uncertainty in the diets (see e.g. Stenson and Perry 2001 for methods).

Determination of the fatty acid signatures of blubber is a new approach to determining diet (e.g. Iverson *et al*. 1997). This approach has been used previously to indicate that animals from different areas feed on different prey and that diets vary between different time periods. Preliminary results from a study on harp seal diets shows that seals collected from nearshore and offshore areas appear to have different diets. Recently, a new modelling approach has been developed that can determine the proportion of prey in the diets (S. Iverson, personal communication). This approach has been used on grey seals from Sable Island and provides information on the diet of seals integrated over several months.

A variety of methods can be used to determine the diet of seals. Each of these methods has specific advantages and disadvantages and provides data to answer different questions. Understanding the strengths of limitations of each method will allow researchers to combine data from each to answer the questions posed.

Table 14 Some advantages and disadvantages associated with different methods of determining diet

Method	Advantages	Disadvantages
Stomach Contents	• Identify species, size and numbers consumed • Minimal digestion • Analyses based on individuals • Geographic and seasonally restricted	• Differential digestion of prey • Error associated with reconstructions • Relies on hard parts • Geographic and seasonally restricted • Labour intensive
Faecal Contents	• Identify species, size and possibly numbers consumed • Geographic and seasonally restricted (perhaps less than stomachs) • Non invasive • Easier to process than stomachs	• Increased degree of digestion cf. stomachs • Errors associated with reconstructions • Relies on hard parts • Geographic and seasonally restricted • Relationship to single meal unknown • Analyses not individual based • Not available for all species
Fatty Acid Analyses	• Diet geographic and seasonally integrated • Analyses based on individuals • Recognize differences in overall diet • Identify species consumed • Minimally invasive • Potentially cost-effective	• Extensive prey library • Library may require updating • Ability to determine prey size limited? • Diet geographic and seasonally integrated • Requires specialized training and equipment
Stable Isotopes	• Trophic level of consumption • Stable C and O can provide information on locations of foraging • Can be used to indicate biases in other methods • Easily collected • Inexpensive • Analyses based on individuals • Geographic and seasonally integrated	• Limited ability to identify prey species • Requires extensive prey library • Library may require updating • Geographic and seasonally integrated • Requires specialized training and equipment
DNA Analyses	• Identify species consumed • Does not require hard parts • Geographic and seasonally restricted • Analyses individual based (Stomachs)	• Does not identify prey size or numbers • DNA library required • Geographic and seasonally restricted • Labour intensive • Requires specialized training and equipment
Direct Observations	• Identify species, size and number consumed • No digestion corrections required • Can be linked to foraging effort • Analyses based on individuals	• Require recapture of individual • May not be applicable for some species • Limited sample size • Currently expensive • Analyses may be time consuming
Indirect Observations	• Identifies spatial and temporal foraging behaviour • Analyses based on individuals	• Does not identify diet • Expensive • Small sample sizes

Diet studies conducted by SevPINRO were reviewed (Svetocheva, this meeting, SEA-128). Methods employed are similar to those used by Norwegian, Greenland, and Canadian researchers for stomach and intestinal content analyses. Studies of quantitative consumption and accounts of basic parameters including a daily food budget (DFB), daily energy budget (DEB), and daily time budget (DTB) are based on data collected from observations of animals in their natural habitat, in captivity, and by simulation of feeding situations.

Finally, PINRO studies of the seasonal distribution and movements of harp seals in the White and Kara Seas were presented (Zirjanov, this meeting SEA-130). Determination of the role of White Sea harp seals in the ecosystem of the Barents and Kara Seas, and their influence on the resources and food base of the commercial fish species is impossible without knowing the character of migrations and food composition (diets) by season and area. Therefore, to determine the influence of harp seals on the ecosystem as a whole it is important to determine correctly and to mark out feeding grounds, in terms of their seasonal usage, food composition and approximate abundance of seals on each feeding ground. The data on migration areas in the Barents Sea, as well as for the whole Kara Sea, is especially needed. PINRO proposes to study the feeding grounds in different seasons in order to optimize the further analysis of harp seals diets.

The Working Group then summarized the recommendations they considered relevant from these presentations. Note that this topic was not part of the Terms of Reference from ACFM, and WGHARP took it upon itself to review methods.

WGHARP **recommended** that for future diet studies:

a) It is useful to combine methods of estimating the importance of different prey species

b) Samples be obtained over the range of the question you are trying to address

c) Local (time/space) data should be used for regressions and that additional research be considered to determine if seasonal variations occur

d) Researchers must recognize and quantify variability in their estimates

e) WGHARP consider a set of standardized guidelines or handbook for diet studies that includes data analysis techniques

f) Seasonal and annual variation in the energy content of the prey be quantified

g) The age distribution of prey be determined and be made available for ecological models

h) WGHARP views its future role in diet studies as a review body and not one to prepare consumption estimates

It was also suggested that the pros and cons of various methods (Table 14) be considered by researchers in designing their diet studies.

8 ADVICE FOR ACFM and NAFO

The Chair of the Working Group will prepare a draft of this advice based on the results of this meeting and past precedent, and circulate this to the Working Group for their review. A summary of the results of this meeting will also be submitted to NAFO.

9 FUTURE ACTIVITIES OF THE WORKING GROUP

The Working Group will meet by correspondence during 2004. The next physical meeting is tentatively planned for late summer-early fall of 2005. An invitation by the Northwest Atlantic Fisheries Centre to host the meeting in St. John's

Canada will be discussed by correspondence. The Group will continue to report to ACFM and NAFO on an annual basis.

The modelling subgroup agreed that additional studies to address the recommendations of the Workshop on Providing Improved Advice proceed on two fronts intersessionally. The first, led by Hans Skaug, will be to continue development of the current model and, more specifically, to explicitly incorporate uncertainty from biological parameters into the model. The second effort will be to conduct the various sensitivity analyses recommended by the Workshop. This will be led by Alf Harbitz with assistance (by correspondence) from other scientists in the group, especially Russian scientists. The various workshop recommendations will be dealt with as follows:

1. Comparison of model formulations:

    a. NE vs NW – will be attempted as part of the sensitivity analysis
    b. NE vs Simple replacement yield model – will clarify how relevant this is to the new model, and if of significance, will conduct the comparison
    c. NE vs Ulltang – not considered relevant because models are so similar

2. Advice on Model Formulations – Sensitivity Simulations

    a. Run NE model starting in 20th century w/out K assumption – done
    b. Run NE model removing various data components – not relevant for current model because little data to remove
    c. Evaluate sensitivity to input parameters – will be performed
    d. Evaluate importance of valid age structure – not relevant, because the current model does not have age structure input
    e. Track survival rates for realism – will be performed
    f. Run models with real and simulated data sets – will be performed
    g. Density dependence – not relevant because it has been removed from model

It was proposed to finish all of this work over the next year and to present a brief progress report to WGHARP by September 2004 via correspondence. Full discussion of the results will discuss at the 2005 Working Group meeting.

It was suggested that a small group collaborate via correspondence to further develop ways to apply the Precautionary Approach to providing advice for harps and hoods. One of the first issues to be addressed is to develop definitions for biological reference points. The sub-group would consist of Hammill, Haug, Merrick, Filin, and Stenson. The rest of the group would be informed via email.

Issues that will be addressed by the Working Group at the next meeting (2005) may include, but are not limited to:

1) Further development of biological reference points for harp and hooded seals
2) Review of the results of intercessional modelling studies to look at sensitivity analyses and comparisons among models.
3) Review of results of proposed pup production surveys in the NW Atlantic.
4) Address requests for advice from parent organizations, as required.

10 RECOMMENDATIONS

The Working Group discussed future research priorities and **recommends** that:

1. Regular surveys of abundance must be completed for all stocks of harp and hooded seals, and research efforts between survey years should be focused on:

    a. Analysis of the past and future photographic surveys should include estimation of bias due to reader's errors, and further clarification of the methods used to determine the temporal distribution of whelping.
    b. Improving survey techniques among areas, and
    c. Collection of relevant biological data required for population assessments.

2. All available biological samples should be analyzed and presented to the Working Group to allow assessment of biological parameters.

3. Studies on harp and hooded seal diet with concurrent estimates of prey availability should be continued.

4. Telemetry studies should be continued to provide information on movements, activity patterns, and bioenergetics.

5. Pup production estimates and reproductive parameters of hooded seals in the all areas should be collected and analysed as soon as possible.

6. The work to implement biological reference points for seal management should continue (see Section 3).

7. With respect to population models:

   a. The work to implement the recommendations of the modelling workshop should be continued (see Sections 3 and 9).
   b. In the absence of information on the level of natural mortality, estimation of M should be incorporated into the fitting procedure.

8. With respect to future diet studies:

   a) Different methods of estimating the importance of different prey species should be combined
   b) Samples must be obtained over the range of the question you are trying to address
   c) Local (time/space) data should be used for regressions and that additional research be considered to determine if seasonal variations occur
   d) Seasonal and annual variations in the energy content of the prey be quantified
   e) Researchers must recognize and quantify variability in their estimates
   f) The age distribution of prey be determined and be made available for ecological models
   g) WGHARP should consider if a set of standardized guidelines or handbook for diet studies that includes data analysis techniques would be useful
   h) WGHARP views its future role in diet studies as a review body and not one to prepare consumption estimates

11 Other business

Hunters in Greenland have reported the occurrence of a large number of harp seals with large areas of missing hair. The Working Group was asked for information concerning the occurrence of this phenomenon in other areas and potential causes. The discussion revealed that the occurrence of seals with missing hair is not a new phenomenon. In other areas, it has been observed both recently and historically in harp, hooded, grey, harbour, bearded and ringed seals. However, it tends to be uncommon in most areas. The cause of the hair loss is not known, but it was suggested that it may be due to a vitamin deficiency or the result of stress. The presence of a fungal infection, *Mycotic dermatitis* (Frasca et al 1996) has also been associated with hair loss in captive harbour seals. The Working Group concluded that hair loss may be a natural, but relatively rare occurrence in harp and hooded seals.

12 ADOPTION OF THE REPORT

The report was adopted by the Working Group at 1835 MST, 6 September 2003.

APPENDIX I

PARTICIPANTS

NAME	ADDRESS	TELEPHONE	FAX	E-MAIL
Dr. T. Haug (Chairman)	Institute of Marine Research, Tromsø Branch, PO Box 6404, N-9294 Tromsø Norway	+47 776 09722	+47 776 09 701	toreha@imr.no
Mr G. Bøthun	Institute of Marine Research, PO Box 1870 Nordnes, N-5817 Bergen Norway	+47 55 238608	+47 55 238617	gjermund@imr.no
Dr. V. Chernook	Polar Research Institute of Marine Fisheries and Ocean-ography (PINRO) 6 Knipovich Street 183763 Murmansk Russia	+7 815 247 3666	+7 512 951 0518 +7 815 247 3331	chernook@pinro.ru
Dr. A. Filin	Polar Research Institute of Marine Fisheries and Ocean-ography (PINRO) 6 Knipovich Street 183763 Murmansk Russia	+7 815 247 2962	+7 512 351 0518	filin@pinro.ru
Ms A.K.H. Frie	Institute of Marine Research, Tromsø Branch, PO Box 6404, N-9294 Tromsø Norway	+47 776 09729	+47 776 09701	anne.kristine.frie@imr.no
Dr A. Golikov	SevPINRO, Uritskogo 17, 162002 Archangelsk, Russia	+7 818 2 661649	+7 818 2 661650	golikov@sevpinro.ru
Dr M. Hammill	Dept. of Fisheries and Oceans P.O. Box 1000 Mont-Joli, Québec G5H 3Z4 Canada	+1 418 775 0581	+1 418 775 0542	hammillm@dfo-mpo.gc,ca
Dr A. Harbitz	Institute of Marine Research, Tromsø Branch, PO Box 6404, N-9294 Tromsø Norway	+47 776 09731	+47 776 09701	alf.harbitz@imr.no
Ms. S. Kornilova (Interpreter)	Polar Research Institute of Marine Fisheries and Ocean-ography (PINRO) 6 Knipovich Street 183763 Murmansk Russia	+7 815 247 2395	+7 815 247 3331	inter@pinro.ru
Mr V. Korzhev	Polar Research Institute of Marine Fisheries and Ocean-ography (PINRO) 6 Knipovich Street 183763 Murmansk Russia	+7 815 247 2469	+7 815 247 3331	korzhev@pinro.ru

NAME	ADDRESS	TELEPHONE	FAX	E-MAIL
Mr. N. Kuznet-sov	Polar Research Institute of Marine Fisheries and Ocean-ography (PINRO) 6 Knipovich Street 183763 Murmansk, Russia	+7 815 223 7957	+7 815 247 3331	nikuz@yandex.ru
Dr. R. Merrick	National Marine Fisheries 166 Water Street Woods Hole, Maine 02543 U.S.A.	+1 508 495 2291	+1 508 495 2258	richard.merrick@noaa.gov
Dr. K. T. Nilssen	Institute of Marine Research, Tromsø Branch, PO Box 6404, N-9294 Tromsø Norway	+47 776 09724	+47 776 09701	kjelltn@imr.no
Mr A. Rosing-Asvid	Greenland Institute for Natural Resources, PO Box 570, GL-3900 Nuuk, Greenland	+299 321095	+299 325957	aqqalu@natur.gl
Mr. S. Sennikov (Interpreter)	Polar Research Institute of Marine Fisheries and Ocean-ography (PINRO) 6 Knipovich Street 183763 Murmansk, Russia	+7 815 247 2395	+7 815 247 3331	sennikov@pinro.ru
Mr. I. Shaphikov	Polar Research Institute of Marine Fisheries and Ocean-ography (PINRO) 6 Knipovich Street 183763 Murmansk, Russia	+7 815 247 2395	+7 815 247 3331	ils@pinro.ru
Dr. H. J. Skaug	Institute of Marine Research P.O. Box 1870 Nordnes 5817 Bergen Norway	+47 55 238604	+47 55 238617	skaug@imr.no
Mr. V. Stasenkov	SevPINRO, Uritskogo 17, 162002 Archangelsk, Russia	+7 818 266 1651	+7 818 266 1650	stasenkov@sevpinro.ru
Dr. G. Stenson	Dept. of Fisheries and Oceans St. John’s, Newfoundland A1C 5X1 Canada	+1 709 772 5598	+1 709 772 4105	stensong@dfo-mpo.gc.ca
Ms O. Sveto-cheva	SevPINRO, Uritskogo 17, 162002 Archangelsk, Russia	+7 818 2 661649	+7 818 2 661650	lmm@sevpinro.ru
Dr. V. Svetochev	SevPINRO, Uritskogo 17, 162002 Archangelsk, Russia	+7 818 2 661649	+7 818 2 661650	lmm@sevpinro.ru
Mr. K. Zharikov	VNIRO, Ul. Verkhnjaja Krasnoselskaya 17, 107140 Moscow, Russia	+7 095 264 9210	+7 095 264 9187	zharikov@vniro.ru
Mr. S. Ziryanov	Polar Research Institute of Marine Fisheries and Ocean-ography (PINRO) 6 Knipovich Street 183763 Murmansk, Russia	+7 815 247 4278	+7 815 247 3331	ziryanov@pinro.ru

APPENDIX II

AGENDA

1. Opening Remarks
2. Meeting Arrangements
    - 2..1. Meeting Schedule
    - 2.2 Appointment of Rapporteur(s)
    - 2.3 Review of Terms of Reference
    - 2.4 Adoption of the Agenda
    - 2.5 Review of Documentation
3 Review of recommendations from the "Workshop to Develop Improved Methods for Providing Harp and Hooded Seal Harvest Advice"
4 Harp Seals (*Phoca groenlandica*)
    - 4.1 Stock identity, Distribution and Migrations
    - 4.2 The Greenland Sea Stock
        - 4.2.1 Information on recent catches and regulatory measures
        - 4.2.2 Current research
        - 3.2.3 Biological parameters
        - 4.2.4 Population assessment
        - 4.2.5 Catch options
    - 4.3 The White Sea and Barents Sea Stock
        - 4.3.1 Information on recent catches and regulatory measures
        - 4.3.2 Current research
        - 4.3.3 Biological parameter
        - 4.3.4 Population assessment
        - 4.3.5 Catch options
    - 4.4 The Northwest Atlantic Stock
        - 4.4.1 Information on recent catches and regulatory measures
        - 4.4.2 Current research
        - 4.4.3 Biological parameters
        - 4.4.4 Information on the state of the stock
5. Hooded Seals (*Cystophora cristata*)
    - 5.1 Stock Identity, Distribution and Migrations
    - 5.2 The Greenland Sea Stock
        - 5.2.1 Information on recent catches and regulatory measures
        - 5.2.2 Current research
        - 5.2.3 Biological parameters
        - 5.2.4 Population assessment
        - 5.2.5 Catch options
    - 5.3 The Northwest Atlantic Stock
        - 5.3.1 Information on recent catches and regulatory measures
        - 5.3.2 Current research
        - 5.3.3 Biological parameters
        - 5.3.4 Information on the state of the stock
6. Biological Reference points for NE Atlantic harp and hooded seals
7. Predation on commercially important fish species by harp and hooded seals – review of diet and consumption studies, with particular emphasis on methodology.
8. Draft advice for ACFM
9. Future activities of the Working Group
10. Recommendations
11. Other Business
12. Adoption of Report

APPENDIX III

REFERENCES

I. Working Documents Presented at the Meeting

SEA No.	Section	Title
115	4.2.1 4.3.1 5.2.1	Haug,T. and V. Svetochev. 2003. Norwegian and Russian catches of harp and hooded seals in the Greenland Sea and in the Barents Sea/White Sea in 2001-2003.
116	4.2.1	Haug, T., G. B. Stenson, P. J. Corkeron and K. T. Nilssen. 2003. Estimation of harp seal (*Pagophilus groenlandicus*) pup production in the North Atlantic completed: Results from surveys in the Greenland Sea in 2002.
117	7	Corkeron, P. 2003. Another look at gut contents
118	4.4.1 5.3.1	Stenson, G. 2003. Canadian catches of harp and hooded seals in the Northwest Atlantic 200-2003
119	7	Rosing-Asvid A. 2003. Methodology used in diet and consumption studies of harp seals in Greenland.
120	7	Hammill, M. O., V. Lesage, F. Proust and P. Carter. 2003. Preliminary findings on the problems associated with determining diet composition in pinnipeds by reconstruction of stomach contents of faecal samples.
121	7	Nilssen, K. and T. Haug. 2003. Methods applied in seal diet and prey consumption studies
122	4.3.4	Chernook, V.I., I. N. Shafikov, N. V. Kuznetsov, S. A. Yegorov, V. A. Tereshchenko, and V. V. Asjutenko. 2003. Preliminary estimation of harp seal pups numbers on whelping patches in 2003.
123	4.3.4	Chernook, V. I. and N. V. Kuznetsov. 2003. Results of the harp seal pups aerial surveys of the White Sea population in 2002
124	4.3.4	Chelintsev, N.G. 2003. Extrapolation algorithm for aerial assessments of animals on parallel routes.
125	6	Filin, A.A. 2003. Precautionary approach applied for the management of the harp seal from the White Sea population
126	4.3.4	Korzhev, V.A. 2003. Modeling the dynamics of the harp seal population abundance
127	4.3.3	SevPINRO. 2003. Age distribution in Russian catches of harp seals in the White Sea, 1959-1996
128	7	Svetochev, O. N. 2003. Approaches to study of diet and food consumption of seals, feeding habits of White Sea harp seal population (*Phoca groenlandica*)
129	6	Svetochev, V. N. and A. P. Golikov. 2003. Harvest and estimations of the White Sea harp seal stock conditions in 1920-2003
130	7	Zirjanov, S. V. 2003. Study of the seasonal distribution of harp seal in the White Sea population for the assessment its role in ecosystem

131	4.2.3 4.3.3	Frie, A. K., O. Svetochev, L. Lindblom, N-E. Skavberg, P. Corkeron, and T. Haug. 2003. Preliminary results of a Russian/Norwegian crossreading experiment on age determination of harp seals *Pagophilus groenlandicus*
132	4.2.5 4.3.5 5.2.5	Bøthun,G., A. Harbitz, A. Golikov, V. Korzhev and H. Skaug. Assessment and prognoses for Greenland Sea harp seals, White Sea/Barents Sea harp seals, ad Greenland Sea hooded seals.

II. Other Background Documents

Section	Title
7	Barros, N.B. and M.R. Clarke. 2002. Diet. In: Perrin WF, Würsig B, Thewissen JGM, editors. Encyclopedia of Marine Mammals. Academic Press, San Diego, San Fransisco, New York, Boston, London, Sydney, Tokyo. P. 323-327.
11	Frasca, S., J. L. Dunn, J. C. Clooke and J. D. Buck. 1996 *Mycotic dermatitis* in an Atlantic white-sided dolphin, a pygmy sperm whale and two harbour seals. J. Am. Vet. Med. Assoc. 208:727-729
4.2.1 4.3.3	Frie, A. K., V. A. Potelov, M.C.S. Kingsley and T. Haug, 2003. Trends in age-at-maturity and growth parameters of female Northeast Atlantic harp seals, *Pagophilus groenlandicus* (Erxleben, 1777) ICES J. Mar. Sci 60: 1018-1032.
6.	Hammill, M.O. and G. B. Stenson. 2003a. Application of the precautionary approach and conservation reference points to the management of Atlantic seals: A discussion paper CSAS Res. Doc. 2003/067
4.4.4	Hammill, M.O. and G. B. Stenson 2003b. Harvest simulations for 2003-2006 harp seal management plan CSAS Res. Doc 2003/068
7	Haug, T., K. Nilssen, P. Corkeron and L. Lindblom 2002. Diets of harp and hooded seals in drift ice waters along the east coast of Greenland. NAMMCO Sc. Comm. WP SC/10/16.
6	ICES. 2001. Report of the study group on further developments of the precautionary approach to fishery management. ICES CM 2001/ACFM:11
3.6	ICES. 2003. Report of the workshop to develop improved methods for providing harp and hooded seal harvest advice. ICES CM 2003/ACFM:13.
7	Iverson, S., K.J. Frost and L.F. Lowry. 1997. Fatty acid signatures reveal fine scale structure of foraging distribution of harbor seals and their prey in Prince William Sound, Alaska. Marine Ecology Progress Series 151: 255-271.
4.3.4	Kingsley, M. C. S., I. Stirling, and W. Calvert. 1985. The distribution and abundance of seals in the Canadian high Arctic. Canadian Journal of Fisheries and Aquatic Sciences 42:1189-1210.
4.3.3	Kjellqwist, S.A., T. Haug, And T. Øritsland. 1995. Trends in age-composition, growth and reproductive parameters of Barents Sea harp seals, *Phoca groenlandica*. ICES J. Mar. Sci. 52: 197-208.
7	NAMMCO. 2002. Report of the NAMMCO Scientific Working Group Marine Mammals: From feeding behaviour or stomach contents to annual consumption – What are the main uncertainties? NAMMCO Annual Report, pp. 191-212.
4.2.4	Øien N., and T. Øristland. 1995. Use of mark-recapture experiments to monitor seal populations subject to catching. In: Whales, Seals, Fish and Man. Blix L, L. Walleø, and Ø. Ulltang), pp. 35-45. Elsevier Science B.V., Amsterdam.
7	Pierce G.J. and P.R. Boyle. 1991. A review of methods for diet analysis in piscivorous marine mammals*. Oceanography and Marine Biology: Annual Review 29 : 409-486.*

4.3.4 Potelov, V. A., A.P. Golikov and V.A. Bondarev, 2003. Estimated pup production of harp seals, *Pagophilus groenlandicus* in the White Sea, Russia, in 2000. ICES J. Mar. Sci. 60: 1012-1017.

4.4.4 Roff, D. and W. D. Bowen. 1985. Further analysis of population trends in the Northwest Atlantic harp seal (Phoca groenlandica) from 1967 to 1985. Can. J. Fish. Aquat. Sci. 43: 553-564.

7 Stenson, G. B. and E. A. Perry. 2001. Incorporating uncertainty into estimates of Atlantic cod (*Gadus morhua*), capelin (*Mallotus villosus*), and Arctic cod (*Boreogadus saida*) consumption by harp seals (*Pagophilus groenlandicus*) in NAFO Divisions 2J3KL. CSAS Res. Doc 2001/074.

5.2.5 Wade, P.R. 1998. Calculating limits to the allowable human-caused mortality of cetaceans and pinnipeds. Marine Mammal Science 14: 1-37.

5.2.5 Wade, P.R., and R.P. Angliss. 1997. Guidelines for assessing marine mammal stocks: Report of the GAMMS workshop April 3–5, 1996, Seattle, Washington. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12, 93 pp. Available at: http://nmml.sfsc.noaa.gov/library/gammsrep/gammsrep.htm

4.3.4 Zabavnikov, V. B., V. I Chernook, S. V. Zyryanov, S. A. Egorov, K. T. Nilssen, A. K. H. Frie, P. Corkeron, and U. Lindstron. 2002. Preliminary results of the joint Russian-Norwegian airborne research in the Barents Sea in September-October 2002. IMR/PINRO Joint Report Series No. 8. 18 pp.

APPENDIX IV

CATCHES OF HARP AND HOODED SEALS

INCLUDING CATCHES TAKEN ACCORDING TO SCIENTIFIC PERMITS

Table 1. Catches of **hooded seals** in the Greenland Sea ("West Ice"), 1946–2003[a], incl. catches for scientific purposes.

	Norwegian catches			Russian catches			Total catches		
Year	Pups	1 year and older	Total	Pups	1 year and older	total	Pups	1 year and older	Total
1946–50	31152	10257	41409	-	-	-	31152	10257	41409
1951–55	37207	17222	54429	-	-	-[b]	37207	17222	54429
1956–60	26738	9601	36339	825	1063	1888[b]	27563	10664	38227
1961–65	27793	14074	41867	2143	2794	4937	29936	16868	46804
1966–70	21495	9769	31264	160	62	222	21655	9831	31486
1971	19572	10678	30250	-	-	-	19572	10678	30250
1972	16052	4164	20216	-	-	-	16052	4164	20216
1973	22455	3994	26449	-	-	-	22455	3994	26449
1974	16595	9800	26395	-	-	-	16595	9800	26395
1975	18273	7683	25956	632	607	1239	18905	8290	27195
1976	4632	2271	6903	199	194	393	4831	2465	7296
1977	11626	3744	15370	2572	891	3463	14198	4635	18833
1978	13899	2144	16043	2457	536	2993	16356	2680	19036
1979	16147	4115	20262	2064	1219	3283	18211	5334	23545
1980	8375	1393	9768	1066	399	1465	9441	1792	11233
1981	10569	1169	11738	167	169	336	10736	1338	12074
1982	11069	2382	13451	1524	862	2386	12593	3244	15837
1983	0	86	86	419	107	526	419	193	612
1984	99	483	582	-	-	-	99	483	582
1985	254	84	338	1632	149	1781	1886	233	2119
1986	2738	161	2899	1072	799	1871	3810	960	4770
1987	6221	1573	7794	2890	953	3843	9111	2526	11637
1988	4873	1276	6149[c]	2162	876	3038	7035	2152	9187
1989	34	147	181	-	-	-	34	147	181
1990	26	397	423	0	813	813	26	1210	1236
1991	0	352	352	458	1732	2190	458	2084	2542
1992	0	755	755	500	7538	8038	500	8293	8793
1993	0	384	384	-	-	-	0	384	384
1994	0	492	492	23	4229	4252	23	4721	4744
1995	368	565	933	-	-	-	368	565	933
1996	575	236	811	-	-	-	575	236	811
1997	2765	169	2934	-	-	-	2765	169	2934
1998	5597	754	6351	-	-	-	5597	754	6351
1999	3525	921	4446	-	-	-	3525	921	4446
2000	1346	590	1936	-	-	-	1346	590	1936
2001	3129	691	3820	-	-	-	3129	691	3820
2002	6456	735	7191	-	-	-	6456	735	7191
2003	5206	77	5283[d]	-	-	-	5206	77	5283[d]

[a] For the period 1946–1970 only 5-year averages are given.

[b] For 1955, 1956 and 1957 Soviet catches of harp and hooded seals reported at 3,900, 11,600 and 12,900, respectively (Sov. Rep. 1975). These catches are not included.

[c] Including 1048 pups and 435 adults caught by one ship which was lost.

[d] Preliminary numbers.

Table 2. Catches of **harp seals** in the Greenland Sea (“West Ice”), 1946–2003[a], incl. catches for scientific purposes.

	Norwegian catches			Russian catches			Total catches		
Year	Pups	1 year And Older	Total	pups	1 year And Older	total	Pups	1 year And Older	Total
1946–50	26606	9464	36070	-	-	-	26606	9464	36070
1951–55	30465	9125	39590	-	-	-[b]	30465	9125	39590
1956–60	18887	6171	25058	1148	1217	2365[b]	20035	7388	27423
1961–65	15477	3143	18620	2752	1898	4650	18229	5041	23270
1966–70	16817	1641	18458	1	47	48	16818	1688	18506
1971	11149	0	11149	-	-	-	11149	0	11149
1972	15100	82	15182	-	-	-	15100	82	15182
1973	11858	0	11858	-	-	-	11858	0	11858
1974	14628	74	14702	-	-	-	14628	74	14702
1975	3742	1080	4822	239	0	239	3981	1080	5061
1976	7019	5249	12268	253	34	287	7272	5283	12555
1977	13305	1541	14846	2000	252	2252	15305	1793	17098
1978	14424	57	14481	2000	0	2000	16424	57	16481
1979	11947	889	12836	2424	0	2424	14371	889	15260
1980	2336	7647	9983	3000	539	3539	5336	8186	13522
1981	8932	2850	11782	3693	0	3693	12625	2850	15475
1982	6602	3090	9692	1961	243	2204	8563	3333	11896
1983	742	2576	3318	4263	0	4263	5005	2576	7581
1984	199	1779	1978	-	-	-	199	1779	1978
1985	532	25	557	3	6	9	535	31	566
1986	15	6	21	4490	250	4740	4505	256	4761
1987	7961	3483	11444	-	3300	3300	7961	6783	14744
1988	4493	5170	9663[c]	7000	500	7500	11493	5670	17163
1989	37	4392	4429	-	-	-	37	4392	4429
1990	26	5482	5508	0	784	784	26	6266	6292
1991	0	4867	4867	500	1328	1828	500	6195	6695
1992	0	7750	7750	590	1293	1883	590	9043	9633
1993	0	3520	3520	-	-	-	0	3520	3520
1994	0	8121	8121	0	72	72	0	8193	8193
1995	317	7889	8206	-	-	-	317	7889	8206
1996	5649	778	6427	-	-	-	5649	778	6427
1997	1962	199	2161	-	-	-	1962	199	2161
1998	1707	177	1884	-	-	-	1707	177	1884
1999	608	195	803	-	-	-	608	195	803
2000	6328	6015	12343	-	-	-	6328	6015	12343
2001	2267	725	2992	-	-	-	2267	725	2992
2002	1118	114	1232	-	-	-	1118	114	1232
2003	161	2116	2277[d]	-	-	-	161	2116	2277[d]

[a] For the period 1946–1970 only 5-year averages are given.

[b] For 1955, 1956 and 1957 Soviet catches of harp and hooded seals reported at 3,900, 11,600 and 12,900, respectively (Sov. Rep. 1975). These catches are not included.

[c] Including 1431 pups and one adult caught by a ship which was lost.

[d] Preliminary numbers.

Table 3 Norwegian **sealing effort** in the Greenland Sea ("West Ice"), 1946–2003[a].

Year	Number of trips/boats	Crew number Total	Crew number Average	Average duration of trips (days)	Average tonnage Gross	Average tonnage Net	Average Horse-Power
1946–50	37	588	16	43	119	42	195
1951–55	45	760	17	40	140	49	277
1956–60	43	702	16	50	137	47	282
1961–65	40	652	16	47	140	48	337
1966–70	24	370	15	42	152	52	500
1971	18	242	13	23	154	51	548
1972	20	256	13	42	165	56	551
1973	16	202	13	37	164	55	526
1974	16	200	13	42	163	55	561
1975	15	188	13	39	163	54	573
1976	15	188	13	51	174	61	650
1977	13	156	12	43	174	61	642
1978	11	132	12	42	198	73	773
1979	10	130	13	46	224	84	910
1980	9	115	13	52	266	107	1034
1981	7	91	13	52	281	119	1070
1982	6	84	14	36	334	134	1348
1983	2	.	(10)	39	352	144	1325
1984	2	.	(10)	41	237	86	970
1985	1	11	11	37	178	72	940
1986	2	.	.	.	.	.	.
1987	5	.	.	.	.	.	.
1988	7(6)[b]	.	.	.	.	.	.
1989	3	.	.	.	.	.	.
1990	3	41	14	.	.	.	.
1991	2	26	13	.	.	.	.
1992	3	.	.	.	.	.	.
1993	2	.	.	.	.	.	.
1994	2	.	.	.	.	.	.
1995	2	.	.	.	.	.	.
1996	2	.	.	.	.	.	.
1997	1	.	.	.	.	.	.
1998	4	.	.	.	.	.	.
1999	2	.	.	.	.	.	.
2000	2	.	.	.	.	.	.
2001	2	.	.	.	.	.	.
2002	3	.	.	.	.	.	.
2003	2	.	.	.	.	.	.

[a] For the period 1946–1970 only 5-year averages are given.

[b] One ship lost.

Table 4. Soviet/Russian **sealing effort** in the Greenland Sea ("West Ice"), 1958–2003[a,b].

Year	Number Of Vessels	Average Crew Number	Average duration of trips (days)	Average tonnage Gross	Net	Average Horse Power
1958–60	6	23	22	200	.	.
1961–65	7	23	45	200	.	.
1966–	4	23	46	200	.	.
1967–74[c]	-	-	-	-	-	-
1975	1	.	45	.	.	.
1976	2	.	24	.	.	.
1977	3	68	16	1971	597	3300
1978	3	.	22	.	.	.
1979	2	.	24	.	.	.
1980	2	.	21	.	.	.
1981	2	.	17	.	.	.
1982	2	.	22	.	.	.
1983	2	.	.	.	.	.
1984	-	-	-	-	-	-
1985	2	.	16	.	.	.
1986	2	.	(11)	.	.	.
1987	2	.	(23)	.	.	.
1988	3	.	.	.	.	.
1989	-	-	-	-	-	-
1990-91	1	.	.	.	.	.
1992	2	.	.	.	.	.
1993	-	-	-	-	-	-
1993-94	1	.	.	.	.	.
1995–2003[c]	-	-	-	-	-	-

[a] Information extracted from the Soviet reports to the Norwegian-Soviet Sealing Commission.

[b] For the period 1958–1965 only average are given.

[c] Soviet/Russian vessels did not participate in the hunt in 1967–1974 and after 1994.

Table 5. Catches of **harp seals** in the White and Barents Seas ("East Ice"), 1946–2003[a,b].

	Norwegian catches			Russian catches			Total catches		
Year	Pups	1 year and older	total	pups	1 year and older	total	Pups	1 year And Older	Total
1946–50			25057	90031	55285	145316			170373
1951–55			19590	59190	65463	124653			144243
1956–60	2278	14093	16371	58824	34605	93429	61102	48698	109800
1961–65	2456	8311	10767	46293	22875	69168	48749	31186	79935
1966–70			12783	21186	410	21596			34379
1971	7028	1596	8624	26666	1002	27668	33694	2598	36292
1972	4229	8209	12438	30635	500	31135	34864	8709	43573
1973	5657	6661	12318	29950	813	30763	35607	7474	43081
1974	2323	5054	7377	29006	500	29506	31329	5554	36883
1975	2255	8692	10947	29000	500	29500	31255	9192	40447
1976	6742	6375	13117	29050	498	29548	35792	6873	42665
1977	3429	2783	6212[c]	34007	1488	35495	37436	4271	41707
1978	1693	3109	4802	30548	994	31542	32341	4103	36344
1979	1326	12205	13531	34000	1000	35000	35326	13205	48531
1980	13894	1308	15202	34500	2000	36500	48394	3308	51702
1981	2304	15161	17465[d]	39700	3866	43566	42004	19027	61031
1982	6090	11366	17456	48504	10000	58504	54594	21366	75960
1983	431	17658	18089	54000	10000	64000	54431	27658	82089
1984	2091	6785	8876	58153	6942	65095	60244	13727	73971
1985	348	18659	19007	52000	9043	61043	52348	27702	80050
1986	12859	6158	19017	53000	8132	61132	65859	14290	80149
1987	12	18988	19000	42400	3397	45797	42412	22385	64797
1988	18	16580	16598	51990	2501[e]	54401	51918	19081	70999
1989	0	9413	9413	30989	2475	33464	30989	11888	42877
1990	0	9522	9522	30500	1957	32457	30500	11479	41979
1991	0	9500	9500	30500	1980	32480	30500	11480	41980
1992	0	5571	5571	28351	2739	31090	28351	8310	36661
1993	0	8758[f]	8758	31000	500	31500	31000	9258	40258
1994	0	9500	9500	30500	2000	32500	30500	11500	42000
1995	260	6582	6842	29144	500	29644	29404	7082	36486
1996	2910	6611	9521	31000	528	31528	33910	7139	41049
1997	15	5004	5019	31319	61	31380	31334	5065	36399
1998	18	814	832	13350	20	13370	13368	834	14202
1999	173	977	1150	34850	0	34850	35023	977	36000
2000	2253	4104	6357	38302	111	38413	40555	4215	44770
2001	330	4870	5200	39111	5	39116	39441	4875	44316
2002	411	1937	2348	34187	0	34187	34598	1937	36535
2003	2343	2955	5298[g]	37936	0	37936	40279	2955	43234[g]

[a] For the period 1946–1970 only 5-year averages are given.

[b] Incidental catches of harp seals in fishing gear on Norwegian and Murman coasts are not included (see Table 6).

[c] Approx. 1300 harp seals (unspecified age) caught by one ship lost are not included.

[d] An additional 250–300 animals were shot but lost as they drifted into Soviet territorial waters.

[e] Russian catches of 1+ animals after 1987 selected by scientific sampling protocols.

[f] Included 717 seals caught to the south of Spitsbergen, east of 14^{O} E, by one ship which mainly operated in the Greenland Sea.

[g] Preliminary numbers.

Table 6. Reported incidental catches and death of **harp seals** at the Norwegian and Murman coasts[1].

Year	Norwegian coast	Murman coast	Total
1979	2023	1114	3137
1980	3311		
1981	2013		
1982	517		
1983	855		
1984	1236		
1985	1225		
1986	4409		
1987	56222		
1988	21538		
1989	314		
1990	368		
1991	1379.		
1992	1583		
1993	2180		
1994	3238		
1995	10616		
1996	2838		
1997	3812		
1998	3575		
1999	488		
2000	439		
2001	0		
2002	12		

[1] Norwegian data are recorded catches, since 1981 recorded for compensation under regulations for damage to fishing gear. No compensation was paid in 1990, 1993, 1996, and 1998-2003.

Table 7. Catches of **moulting hooded seals** in the Denmark Strait, 1945–1978.

Year	Norway Sealing	Greenland sealing[a]	Norway Scient. Sampling
1945	3275	-	-
1946	17767	-	-
1947	16080	-	-
1948	16170	-	-
1949	1494	-	-
1950	17742	-	-
1951	47607	-	-
1952	16910	-	-
1953	2907	-	-
1954	18291	-	-
1955	10230	-	-
1956	12840	-	-
1957	21425	-	-
1958	14950	-	-
1959	6480	414	-
1960	7930	0[b]	-
1961	-	773	-
1962	-	967	-
1963	-	813	-
1964	-	360	-
1965	-	-	-
1966	-	782	-
1967	-	358	-
1968	-	-	-
1969	-	-	-
1970	-	-	797
1971	-	-	-
1972	-	-	869
1973	-	-	-
1974	-	-	1201
1975	-	-	-
1976	-	-	323
1977	-	-	-
1978	-	-	1201

[a] Conducted by **KGH** (Royal Greenland Trade Department) on behalf of the local inhabitants of Ammassalik,
Southeast Greenland.

[b] The vessel was lost 23 June on its first trip that year; previous information on a catch of 773 seals is thus in
error (probably confused with the 1961-catch).

Table 8 Catches of **hooded seals** in West and East Greenland, 1954–2001.

Year	West Atlantic Population				NE	All Greenland
	West	KGH[b]	South-east	Total		
1954	1,097	-	201	1,298	-	1,298
1955	972	-	343	1,315	1	1,316
1956	593	-	261	854	3	857
1957	797	-	410	1207	2	1,209
1958	846	-	361	1207	4	1,211
1959	780	414	312	1,506	8	1,514
1960	965	-	327	1,292	4	1,296
1961	673	803	346	1,822	2	1,824
1962	545	988	324	1,857	2	1,859
1963	892	813	314	2,019	2	2,021
1964	2,185	366	550	3,101	2	3,103
1965	1,822	-	308	2,130	2	2,132
1966	1,821	748	304	2,873	-	2,873
1967	1,608	371	357	2,336	1	2,337
1968	1,392	20	640	2,052	1	2,053
1969	1,822	-	410	2,232	1	2,233
1970	1,412	-	704	2,116	9	2,125
1971	1,634	-	744	2,378	-	2,378
1972	2,383	-	1,825	4,208	2	4,210
1973	2,654	-	673	3,327	4	3,331
1974	2,801	-	1,205	4,006	13	4,019
1975	3,679	-	1,027	4,706	58[a]	4,764
1976	4,230	-	811	5,041	22[a]	5,063
1977	3,751	-	2,226	5,977	32[a]	6,009
1978	3,635	-	2,752	6,387	17	6,404
1979	3,612	-	2,289	5,901	15	5,916
1980	3,779	-	2,616	6,395	21	6,416
1981	3,745	-	2,424	6,169	28[a]	6,197
1982	4,398	-	2,035	6,433	16[a]	6,449
1983	4,155	-	1,321	5,476	9[a]	5,485
1984	3,364	-	1,328	4,692	17	4,709
1985	3,188	-	3,689	6,877	6	6,883
1986	2,796[a]	-	3,050[a]	5,846[a]	-[a]	5,846[a]
1987	2,333[a]	-	2,472[a]	4,805[a]	3[a]	4,808[a]
1988–92[c]						
1993	4,983	-	1,967	6,950	32	6,982
1994	5,060	-	3,048	8,108	34	8,142
1995	4,447		2,702	7,149	48	7,197
1996	6,081	-	3,801	9,882	24	9,906
1997	5,258		2,175	7,433	67	7,500
1998	5,044		1,270	6,314	14	6,328
1999	1,488	-	1,682	3,170	4	3,174
2000	3,773	-	2,046	5,819	29	5,848
2001	4,820	-	1,439	6,259	5	6,264

[a] Provisional figures: do not include estimates for non-reported catches as for the previous years.

[b] Royal Greenland Trade Department special vessel catch expeditions in the Denmark Strait, 1959–68.

[c] For 1988 to 1992 catch statistics are not available.

Table 9a. Catches of **harp seals** in Greenland, 1954–1987 (List-of-Game), and 1993–2001 (Piniarneq), and % adults[a] according to the hunters' reports.

	West Greenland		South East Greenland		North East Greenland		All Greenland
Year	Catch numbers	% adults	Catch numbers	% adults	Catch numbers	% adults	Catch numbers
1954	18,912		475		32		19,419
1955	15,445		178		45		15,668
1956	10,883		180		5		11,068
1957	12,817		133		40		12,990
1958	16,705		360		30		17,095
1959	8,844		168		7		9,019
1960	15,979		350		16		16,345
1961	11,886		219		13		12,118
1962	8,394		211		10		8,615
1963	10,003	21	215	28	20	50	10,238
1964	9,140	26	125	40	7	86	9,272
1965	9,251	25	76	65	2	100	9,329
1966	7,029	29	55	55	6		7,090
1967	4,215	38	54	35	10		4,279
1968	7,026	30	180	47	4		7,210
1969	6,383	21	110	62	9		6,502
1970	6,178	26	182	70	15	100	6,375
1971	5,540	24	63	48	5		5,608
1972	5,952	16	84	48	6	100	6,042
1973	9,162	19	100	20	38	79	9,300
1974	7,073	21	144	29	27	95	7,244
1975	5,953	13	125	20	68	72	6,146
1976	7,787	12	260	48	27	55	8,074
1977	9,938	15	72	16	21	81	10,031
1978	10,540	16	408	14	30	36	10,978
1979	12,774	20	171	19	18	25	12,963
1980	12,270	17	308	14	45		12,623
1981	13,605	21	427	15	49		14,081
1982	17,244	16	267	20	50	60	17,561
1983	18,739	19	357	56	57	30	19,153
1984	17,667	16	525	19	61		18,253
1985	18,445	2	534	0	56	52	19,035
1986	13,932[b]	10	533[b]	18	37[b]	65	14,502[b]
1987	16,053[b]	21	1060[b]	24	15[b]	60	17,128[b]
1988							
1989							
1990	For 1988 to 1992 comparable catch statistics are not available.						
1991							
1992							
1993	55,792	52	1,054	35	40	62	56,886
1994	56,956	51	864	36	88	63	57,908
1995	62,438	50	906	41	61	53	63,405
1996	73,625	52	1,320	33	68	75	75,013
1997	68,313		1,149		201		69,663
1998	80,712		1,670		109		82,491
1999	91,399	50	3,592	12	101	67	95,092
2000	96,092	46	2,529	16	98	67	99,879
2001	76,610	42	2,240	17	71	69	78,921

[a] Seals exhibiting some form of a harp.

[b] These provisional figures do not include estimates for non-reported catches as for the previous years.

Table 9b. Estimated catches of **harp seals** in Greenland, 1975–1987 and 1993–1995. Figures in bold are non-corrected figures from Table 9a.

Year	West Greenland	South East Greenland	North East Greenland	Total Greenland
1975	6,689	**125**	**68**	6,882
1976	11,826	**260**	50	12,136
1977	12,830	**72**	50	12,952
1978	16,434	**408**	50	16,892
1979	17,459	**171**	50	17,680
1980	15,101	**308**	**45**	15,454
1981	22,760	**427**	**49**	23,236
1982	26,793	**267**	**50**	27,110
1983	24,606	**357**	**57**	25,020
1984	25,566	**525**	**61**	26,152
1985	20,518	**534**	**56**	21,108
1986	25,832	**533**[a]	50	26,415
1987	37,329	**1060**[a]	50	38,439
1993	**55,792**	1,335	**40**	57,167
1994	58,811	1,746	**88**	60,645
1995	65,533	1,529	**61**	67,123

[a] Provisional figures; do not include estimates for non-reported catches.

Table 10. **Harp seal** catches off Newfoundland and in the Gulf of St. Lawrence, Canada ("Gulf" and "Front"), 1946–2003[a,b]. Catches from 1995 onward include catches under the personal use licences.

	Large Vessel Catch				Landsmen Catch				Total Catches			
Year	Pups	1+	Unk	Total	Pups	1+	Unk	Total	Pups	1+	Unk	Total
1946-50	108256	53763	0	162019	44724	11232	0	55956	152980	64995	0	217975
1951-55	184857	87576	0	272433	43542	10697	0	54239	228399	98273	0	326672
1956-50	175351	89617	0	264968	33227	7848	0	41075	208578	97466	0	306044
1961-65	171643	52776	0	224419	47450	13293	0	60743	219093	66069	0	285162
1966-70	194819	40444	0	235263	32524	11633	0	44157	227343	52077	0	279420
1971	169426	14343	0	183769	41153	6044	0	47197	210579	20387	0	230966
1972	104109	1646	0	105755	12701	11427	0	24128	116810	13073	0	129883
1973	63369	15081	0	78450	34966	10416	0	45382	98335	25497	0	123832
1974	85387	21828	0	107215	29438	10982	0	40420	114825	32810	0	147635
1975	109832	10992	0	120824	30806	22733	0	53539	140638	33725	0	174363
1976	93939	4576	0	98515	38146	28341	0	66487	132085	32917	0	165002
1977	92904	2048	0	94952	34078	26113	0	60191	126982	28161	0	155143
1978	63669	3523	0	67192	52521	42010	0	94531	116190	45533	0	161723
1979	96926	449	0	97375	35532	27634	0	63166	132458	28083	0	160541
1980	91577	1563	0	93140	40844	35542	0	76386	132421	37105	0	169526
1981[d]	89049	1211	0	90260	89345	22564	0	111909	178394	23775	0	202169
1982	100568	1655	0	102223	44706	19810	0	64516	145274	21465	0	166739
1983	9529	1021	0	10550	40529	6810	0	47339	50058	7831	0	57889
1984	95	549	0	644[e]	23827	7073	0	30900	23922	7622	0	31544
1985	0	1	0	1[e]	13334	5700	0	19034	13334	5701	0	19035
1986	0	0	0	0	21888	4046	0	25934	21888	4046	0	25934
1987	2671	90	0	2761	33657	10356	22	44035	36350	10446	0	46796
1988	0	0	0	0	66972	13493	13581	94046	66972	27074	0	94046
1989	1	231	0	232[e]	56345	5691	3036	65072	56346	8958	0	65304
1990	48	74	0	122[e]	34354	23725	1961	60040	34402	25760	0	60162
1991	3	20	0	23[e]	42379	5746	4440	52565	42382	10206	0	52588
1992	99	846	0	945[e]	43767	21520	2436	67723	43866	24802	0	68668
1993	8	111	0	119[e]	16393	9714	777	26884	16401	10602	0	27003
1994	43	152	0	195[e]	25180	34939	1065	61184	25223	36156	0	61379
1995	21	355	0	376[e]	33615	31306	470	65391	34106	31661	0	65767
1996	3	186	0	189[e]	184853	57864	0	242717	184856	58050	0	242906
1997	0	6	0	6[e]	220476	43728	0	264204	220476	43734	0	264210
1998	7	547	0	554[e]	0	0	282070	282070	7	547	282070	282624
1999	26	25	0	51[e]	221001	6769	16782	244552	221027	6794	16782	244603
2000	16	450	0	466[e]	85035	6567	0	91602	85485	6583	0	92068
2001	0	0	0	0	214754	11739	0	226493	214754	11739	0	226493
2002	0	0	0	0	297764	14603	0	312367	297764	14603	0	312367
2003	0	0	0	0	280174	9338	0	289512	280174	9338	0	289512

[a] For the period 1946-1970 only 5-years averages are given.

[b] All values are from NAFO except where noted.

[c] Landsmen values include catches by small vessels (< 150 gr tons) and aircraft.

[d] NAFO values revised to include complete Quebec catch (Bowen, W.D. 1982)

[e] Large vessel catches represent research catches in Newfoundland and may differ from NAFO values

Table 11. Published values for **harp seal** catches in the Canadian Arctic, 1952–1984.

Year	Bowen[1]			D.E.S.[2]	Roff & Bowen[3]			NAFO[4]	Stewart et al.[5]		
	0	1+	Total	Total	0	1+	Total		N Que	Baffin	N Lab
1952	60	1724	1784								
1953	60	1724	1784								
1954	60	1724	1784								
1955	60	1724	1784								
1956	60	1724	1784								
1957	60	1724	1784								
1958	60	1724	1784								
1959	60	1724	1784								
1960	60	1724	1784								
1961	60	1724	1784								
1962	60	1724	1784								
1963	60	1724	1784								
1964	60	1724	1784								
1965	60	1724	1784								
1966	60	1724	1784								
1967	60	1724	1784								
1968	60	1724	1784								
1969	60	1724	1784								
1970	60	1724	1784								
1971	60	1724	1784								
1972	60	1724	1784								
1973	60	1724	1784								
1974	60	1724	1784	1117							
1975	60	1724	1784	2513							
1976	60	1724	1784	2017					272		
1977	60	1724	1784	1508				1508	306		
1978	60	1724	1784		72	2057	2129	2129	44		
1979	60	1724	1784		128	3492	3620	3707	87		
1980	60	1724	1784		215	6135	6350	6459	52		2062
1981					158	4514	4672	4672		6263	20775
1982					166	4715	4881	4268		5849	1226
1983								1287		2433	86
1984											288

Bowen, W. D. 1982. Age structure of Northwest Atlantic harp seal catches, 1952-80. *NAFO Sci. Coun. Studies*, **3**: 53-65. Mean catch of 1768 for years 1962-1971 from Smith and Taylor (1977) and values of years 1974-1977 reported by Sergeant.

2 Sergeant (pers. comm.) as cited in Bowen (1982).

3 Roff, D. A. and W. D. Bowen. 1986. Further analysis of population trends in the Northwest Atlantic harp seal (*Phoca groenlandica*) from 1967 to 1985. *Can. J. Fish. Aquat. Sci*., **43**: 553-564.

4 Anon. 1985. Provisional report of the Scientific Council. NAFO SCS Doc. 85/I/2. Values include catches in the Northwest Territories and northern Quebec.

5 Stewart, R. E. A., P. Richards, M. C. S. Kingsley and J. J. Houston. 1986. Seals and sealing in Canada's northern and Arctic regions. *Fish. Aquat. Sci. Tech. Rep.*, No. 1463.

Table 12. **Hooded seal** catches off Newfoundland and in the Gulf of St. Lawrence, Canada ("Gulf" and "Front"), 1946–2003[a,b]. Catches from 1995 onward include catches under the personal use licences.

Year	Large Vessel Catches				Landsmaen Catches[c]				Total Catches			
	Pups	1+	Unk	Total	Pups	1+	Unk	Total	Pups	1+	Unk	Total
1946-50	4029	2221	0	6249	429	184	0	613	4458	2405	0	6863
1951-55	3948	1373	0	5321	494	157	0	651	4442	1530	0	5972
1956-60	3641	2634	0	6275	106	70	0	176	3747	2704	0	6451
1961-65	2567	1756	0	4323	521	199	0	720	3088	1955	0	5043
1966-70	7483	5220	0	12703	613	211	24	848	8096	5431	24	13551
1971	7987	6875	0	14862	54	30	0	84	8041	6905	0	14946
1972	6820	5636	0	12456	108	36	0	144	6928	5672	0	12600
1973	4499	1930	0	6429	103	35	0	138	4602	1965	0	6567
1974	5984	3990	0	9974	7	18	0	25	5991	4008	0	9999
1975	7459	7805	0	15264	187	160	0	347	7646	7965	0	15611
1976	6065	5718	0	11783	475	127	0	602	6540	5845	0	12385
1977	7967	2922	0	10889	1003	201	0	1204	8970	3123	0	12093
1978	7730	2029	0	9759	236	509	0	745	7966	2538	0	10504
1979	11817	2876	0	14693	131	301	0	432	11948	3177	0	15125
1980	9712	1547	0	11259	1441	416	0	1857	11153	1963	0	13116
1981	7372	1897	0	9269	3289	1118	0	4407	10661	3015	0	13676
1982	4899	1987	0	6886	2858	649	0	3507	7757	2636	0	10393
1983	0	0	0	0	0	128	0	128	0	128	0	128
1984	206	187	0	393[d]	0	56	0	56	206	243	0	449
1985	215	220	0	435[d]	5	344	0	349	220	564	0	784
1986	0	0	0	0	21	12	0	33	21	12	0	33
1987	124	4	250	378	1197	280	0	1477	1321	284	250	1855
1988	0	0	0	0	828	80	0	908	828	80	0	908
1989	0	0	0	0	102	260	5	367	102	260	5	367
1990	41	53	0	94[d]	0	0	636[e]	636	41	53	636	730
1991	0	14	0	14[d]	0	0	6411[e]	6411	0	14	6411	6425
1992	35	60	0	95[d]	0	0	119[e]	119	35	60	119	214
1993	0	19	0	19[d]	0	0	19[e]	19	0	19	19	38
1994	19	53	0	72[d]	0	0	149[e]	149	19	53	149	221
1995	0	0	0	0	0	0	857[e]	857	0	0	857[e]	857
1996	0	0	0	0	0	0	25754[e]	25754	0	0	25754[e]	25754
1997	0	0	0	0	0	7058	0	7058	0	7058	0	7058
1998	0	0	0	0	0	10148	0	10148	0	10148	0	10148
1999	0	0	0	0	0	0	201 [e]	201	0	0	201	201
2000	2	2	0	4[d]	0	0	10 [e]	10	2	2	10	14
2001	0	0	0	0	0	0	140 [e]	140	0	0	140	140
2002	0	0	0	0	0	0	150 [e]	150	0	0	150	150
2003[f]	0	0	0	0	0	0	151 [e]	151	0	0	151	151

a For the period 1946–1970 only 5-years averages are given.

b All values are from NAFO except where noted.

c Landsmen values include catches by small vessels (< 150 gr tons) and aircraft.

d Large vessel catches represent research catches in Newfoundland and may differ from NAFO values.

e Statistics no longer split by age

f Preliminary estimates

APPENDIX V

SUMMARIES OF SEALING REGULATIONS

Table 1. Summaries of Norwegian sealing regulations for the Greenland Sea ("West Ice"), 1985–2003.

	Opening	Closing	Quotas[1]				Allocations	
	Date	Date	Total	Pups	Fem.	Males	Norway	Soviet/Russia
Hooded Seals								
1985	22 March	5 May	(20,000)[2]	(20,000)[2]	0[3]	Unlim.	8,000[4]	3,300
1986	18 March	5 May	9,300	9,300	0[3]	Unlim.	6,000	3,300
1987	18 March	5 May	20,000	20,000	0[3]	Unlim.	16,700	3,300
1988	18 March	5 May	(20,000)[2]	(20,000)[2]	0[3]	Unlim.	16,700	5,000
1989	18 March	5 May	30,000		0[3]	Incl.	23,100	6,900
1990	26 March	30 June	27,500	0	0	Incl.	19,500	8,000
1991	26 March	30 June	9,000	0	0	Incl.	1,000	8,000
1992-94	26 March	30 June	9,000	0	0	Incl.	1,700	7,300
1995	26 March	10 July	9,000	0	0	Incl.	1,700[7]	7,300
1996	22 March	10 July	9,000[8]				1,700	7,300
1997	26 March	10 July	9,000[9]				6,200	2,800[11]
1998	22 March	10 July	5,000[10]				2,200	2,800[11]
1999-00	22 March	10 July	11,200[12]				8,400	2,800[11]
2001-03	22 March	10 July	10,300[12]				10,300	
Harp Seals								
1985	10 April	5 May	(25,000)[2]	(25,000)[2]	0[5]	0[5]	7,000	4,500
1986	22 March	5 May	11,500	11,500	0[5]	0[5]	7,000	4,500
1987	18 March	5 May	25,000	25,000	0[5]	0[5]	20,500	4,500
1988	10 April	5 May	28,000	0[5,6]	0[5,6]	0[5,6]	21,000	7,000
1989	18 March	5 May	16,000	-	0[5]	0[5]	12,000	9,000
1990	10 April	20 May	7,200	0	0[5]	0[5]	5,400	1,800
1991	10 April	31 May	7,200	0	0[5]	0[5]	5,400	1,800
1992-93	10 April	31 May	10,900	0	0[5]	0[5]	8,400	2,500
1994	10 April	31 May	13,100	0	0[5]	0[5]	10,600	2,500
1995	10 April	31 May	13,100	0	0[5]	0[5]	10,600[7]	2,500
1996	10 April	31 May[8]	13,100[9]				10,600	2,500[11]
1997-98	10 April	31 May	13,100[10]				10,600	2,500[11]
1999-00	10 April	31 May	17,500[13]				15,000	2,500[11]
2001-03	10 April	31 May	15,000[13]				15,000	

1 Other regulations include: Prescriptions for date for departure Norwegian port; only one trip per season; licensing; killing methods; and inspection.
2 Basis for allocation of USSR quota.
3 Breeding females protected ; two pups deducted from quota for each female taken for safety reasons.
4 Adult males only.
5 1 year+ seals protected until 9 April; pup quota may be filled by 1 year+ after 10 April.
6 Any age or sex group.
7 Included 750 weaned pups under permit for scientific purposes.
8 Pups allowed to be taken from 26 March to 5 May.
9 Half the quota could be taken as weaned pups, where two pups equalled one 1+ animal.
10 The whole quota could be taken as weaned pups, where two pups equalled one 1+ animal.
11 Russian allocation reverted to Norway.
12 Quota given in 1+ animals, parts of or the whole quota could be taken as weaned pups, where 1,5 pups equalled one 1+ animal.
13 Quota given in 1+ animals, parts of or the whole quota could be taken as weaned pups, where 2 pups equalled one 1+ animal.

Table 2. Summary of sealing regulations for the White and Barents Seas ("East Ice"), 1979–2003.[1]

Season	Opening dates: Soviet/ Russian	Opening dates: Norwegian sealers	Closing date	Quotas – Allocations: Total	Quotas – Allocations: Soviet/ Russia	Quotas – Allocations: Norway
Harp seals[2]						
1979–80	1 March	23 March	30 April[3]	50,000[4]	34,000	16,000
1981	-	-	-	60,000	42,500	17,500
1982	-	-	-	75,000	57,500	17,500
1983	-	-	-	82,000	64,000	18,000
1984	-	-	-	80,000	62,000	18,000
1985-86	-	-	-	80,000	61,000	19,000
1987	-	-	20 April[3]	80,000	61,000	19,000
1988	-	-	-	70,000	53,400	16,600
1989–94	-	-	-	40,000	30,500	9,500
1995	-	-	-	40,000	31,250	8,750[5]
1996	-	-	-	40,000	30,500	9,500
1997-98	-	-	-	40,000	35,000	5,000
1999	-	-	-	21,400[6]	16,400	5,000
2000	27 Febr	-	-	27,700[6]	22,700	5,000
2001-02	-	-	-	53,000[6]	48,000	5,000
2003	-	-	-	53,000[6]	43,000	10,000

[1] Quotas and other regulations prior to 1979 are reviewed by Benjaminsen, 1979.
[2] Hooded, bearded and ringed seals protected from catches by ships.
[3] The closing date may be postponed until 10 May if necessitated by weather or ice conditions.
[4] Breeding females protected (all years).
[5] Included 750 weaned pups under permit for scientific purposes.
[6] Quotas given in 1+ animals, parts of or the whole quata could be taken as pups, where 2,5 pups equalled one 1+ animal.

Table 3a. Major management measures implemented for harp seals in Canadian waters, 1960–2003.

Year	Management Measure
1961	Opening and closing dates set for the Gulf of the St. Lawrence and Front areas.
1964	First licensing of sealing vessels and aircraft. Quota of 50,000 set for southern Gulf (effective 1965).
1965	Prohibition on killing adult seals in breeding or nursery areas. Introduction of licensing of sealers. Introduction of regulations defining killing methods.
1966	Amendments to licensing. Gulf quota areas extended. Rigid definition of killing methods.
1971	TAC for large vessels set at 200,000 and an allowance of 45,000 for landsmen.
1972 - 1975	TAC reduced to 150,000, including 120,000 for large vessel and 30,000 (unregulated) for landsmen. Large vessel hunt in the Gulf prohibited.
1976	TAC was reduced to 127,000.
1977	TAC increased to 170,000 for Canadian waters, including an allowance of 10,000 for northern native peoples and a quota of 63,000 for landsmen (includes various suballocations throughout the Gulf of St. Lawrence and northeastern Newfoundland). Adults limited to 5% of total large vessel catch.
1978–1979	TAC held at 170,000 for Canadian waters. An additional allowance of 10,000 for the northern native peoples (mainly Greenland).
1980	TAC remained at 170,000 for Canadian waters including an allowance of 1,800 for the Canadian Arctic. Greenland was allocated additional 10,000.
1981	TAC remained at 170,000 for Canadian waters including 1,800 for the Canadian Arctic. An additional allowance of 13,000 for Greenland.
1982–1987	TAC increased to 186,000 for Canadian waters including increased allowance to northern native people of 11,000. Greenland catch anticipated at 13,000.
1987	Change in Seal Management Policy to prohibit the commercial hunting of whitecoats and hunting from large (>65 ft) vessels (effective 1988). Changes implemented by a condition of licence.
1992	First Seal Management Plan implemented.
1993	Seal Protection Regulations updated and incorporated in the Marine Mammal Regulations. The commercial sale of whitecoats prohibited under the Regulations. Netting of seals south of 54°N prohibited. Other changes to define killing methods, control interference with the hunt and remove old restrictions.
1995	Personal sealing licences allowed. TAC remained at 186,000 including personal catches. Quota divided among Gulf, Front and unallocated reserve.
1996	TAC increased to 250,000 including allocations of 2,000 for personal use and 2,000 for Canadian Arctic.
1997	TAC increased to 275,000 for Canadian waters.
2000	Taking of whitecoats prohibited by condition of license
2003	Implementation of 3 year management plan allowing a total harvest of 975,000 over 3 years with a maximum of 350,000 in any one year.

Table 3b. Major management measures implemented for hooded seals in Canadian waters (1960–2003).

Year	Management Measure
1964	Hunting of hooded seals banned in the Gulf area (below 50^{O}N), effective 1965.
1966	ICNAF assumed responsibility for management advice for northwest Atlantic.
1968	Open season defined (12 March–15 April).
1974–1975	TAC set at 15,000 for Canadian waters. Opening and closing dates set (20 March–24 April).
1976	TAC held at 15,000 for Canadian waters. Opening delayed to 22 March. Shooting banned between 23:00 and 10:00 GMT from opening until 31 March and between 24:00 and 09:00 GMT thereafter (to limit loss of wounded animals).
1977	TAC maintained at 15,000 for Canadian waters. Shooting of animals in water prohibited (to reduce loss due to sinking). Number of adult females limited to 10% of total catch.
1978	TAC remained at 15,000 for Canadian waters. Limited number of adult females to 7.5% of total catch.
1979–1982	TAC maintained at 15,000. Catch of adult females reduced to 5% of total catch.
1983	TAC reduced to 12,000 for Canadian waters. Previous conservation measures retained.
1984–1990	TAC reduced to 2,340 for Canadian waters.
1987	Change in Seal Management Policy to prohibit the commercial hunting of bluebacks and hunting from large (>65 ft) vessels (effective 1988). Changes implemented by a condition of licence.
1991–1992	TAC raised to 15,000.
1992	First Seal Management Plan implemented.
1993	TAC reduced to 8,000. Seal Protection Regulations updated and incorporated in the Marine Mammal Regulations. The commercial sale of bluebacks prohibited under the Regulations.
1995	Personal sealing licences allowed (adult pelage only).
1998	TAC increased to 10,000
2000	Taking of bluebacks prohibited by condition of license.