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

30 August - 3 September 2005

St. Johns, Newfoundland, Canada

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Conseil International pour l'Exploration de la Mer

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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 the forthcoming Workshop to Develop Improved Methods for Providing Harp and Hooded Seal Harvest Advise (ICES CM 2001/ACFM:8).

The Workshop to Develop Improved Methods for Providing Harp and Hooded Seal Harvest Advise (ICES CM 2003/ACFM:13) was held in Woods Hole, USA in February 2003.

Based on a request from the Joint Norwegian-Russian Fisheries Commission, and on some outstanding questions from the 2000 meeting, WGHARP met in September 2003 to review recommendations from the "Workshop to Develop Improved Methods for Providing Harp and Hooded Seal Harvest Advise", possibly also to apply recommended models to existing data on harp and hooded seals; to review and discuss existing methods applied in seal diet and consumption studies; to review results from surveys of the 2002 harp seal pup production in the Greenland Sea; to calculate biological limits of yields for Greenland Sea harp seals, Greenland Sea hooded seals, and White Sea / Barents Sea harp seals; and to 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) (ICES CM 2004/ACFM:6).

Following some outstanding questions from the 2003 meeting, ICES and NAFO formulated the following terms of references for WGHARP (Chair: Prof. T. Haug, Norway) to deal with when it met at Department of Fisheries and Oceans, St, John's, Newfoundland, Canada from 30 August – 3 September 2005. These were to:

- Further development of biological reference points for harp and hooded seals;
- Review of the results of intersessional modelling studies to look at sensitivity analyses and comparisons among models
- Review of results of proposed pup production surveys in the NW Atlantic.

WGHARP had established two subgroups to deal with issues i) and ii), respectively, intersessionally. One important conclusion of the subgroup dealing with the biological reference points for harp and hooded seals was that, until updated information about the stocks of hooded becomes available, implementation of biological limits should be restricted to the more 'data-rich' harp seal stocks. Against this background, the Norwegian Royal Ministry of Fisheries and Coastal Affairs, in a letter dated 10 June 2005, has requested ICES to assess and establish biological limits for Greenland Sea harp seals and White Sea/Barents Sea harp seals.

The Norwegian Royal Ministry of Fisheries and Coastal Affairs also requested ICES to assess the status of the stocks of harp and hooded seals in the Greenland Sea and harp seals in the White Sea/Barents Sea.

Furthermore, ICES should assess the impact on these stocks of an annual harvest of:

- Current harvest levels,
- Sustainable catches (defined as the fixed annual catches that stabilizes the future 1+ population),
- Twice the sustainable catches as defined above.

Regarding the third issue above, and following Canada's successful survey of harp seals in the NW Atlantic in 2004, WGHARP received an additional request from the NAFO Scientific Council in a letter dated 5 July, namely to:

- Review the recent assessment of the status of harp seals conducted by Canada and report its findings to the Annual Meeting of Scientific Council during 19-23 September 2005. The Scientific Council also recommended that the WGHARP provide to the same September 2005 Annual Meeting the results of other ongoing studies on harp and/or hooded seals in the NW Atlantic, in particular any available results from tagging studies using satellite telemetry tracking.

WGHARP will report to the ACFM at its October 2005 meeting, as well as the ICES Resource Management and Living Resource Committees. Furthermore, WGHARP will report to the NAFO Scientific Council at its meeting in the fall of 2005.

2 Meeting Arrangements

The Working Group, chaired by T. Haug, and comprised of scientists from Canada, Norway, Russia, and USA met at the Northwest Atlantic Fisheries Centre, Department of Fisheries and Oceans (DFO) in St. John's, Newfoundland, Canada, from 30 August to 3 September 2005.

The Working Group reviewed the report from two subgroups that had worked intersessionally by correspondence with models used in WGHARP's assessments and with the implementation of biological reference points for harp and hooded seals. Furthermore, the group reviewed available information on catches and relevant scientific information on harp and hooded seals, including documents prepared for this meeting. The Agenda adopted for the meeting is shown in Appendix II, and the papers referred to are listed in Appendix III. Hammill, Merrick, Sjare and Stenson agreed to assist the Chair as rapporteurs.

3 Review of report and recommendations from the intersessional modelling subgroup

The Chair of the Modelling subgroup (Skaug) described the work carried out since the last meeting. The terms for reference for the intersessional work were: 1) comparison of model formulations, with special emphasis on applying the NE model to the NW data, and 2) advice on model formulations (sensitivity simulations). A summary of the activities of the working group is presented in the 2004 intersessional report of WGHARP (ICES CM 2005/ACFM:06).

During the intersessional period only limited progress was made on 1), while considerable progress had been made on several sub-items under 2). During the meeting, the subgroup continued to address these issues and significant progress was achieved. Since the last meeting the NE model had been modified to incorporate the estimation of biological parameters (M_{1+}, M_0 and natality rates), rather using them as fixed input. A description of this model is presented in 4.2.4. The comparisons carried out during the current meeting were made using this modified model.

An updated summary of the work carried out by this subgroup before and during the meeting includes:

1. Comparison of model formulations

a) Comparison of NE and NW models

During the meeting, the Modelling subgroup applied data from the NW Atlantic to the modified NE Atlantic model. Available data on reproductive rates were compressed into an ogive curve and a prior distribution for the parameter F of the NE model. The catch series from 1952 was used, and three different options regarding pup-production estimates were considered:

i) All eight available pup production surveys used to fit the model.

ii) Pup production estimates from 1994 and 1999 excluded (Greenland Sea relevant situation).

iii) Pup production estimates from 1994, 1999 and 2004, only (White Sea relevant situation):

The resulting estimates of historical population trends and abundance were very similar to those obtained from the NW Atlantic model. Using all of the estimates, the NE model yielded a total 2005 population of 5.6 million while the corresponding estimate under the NW model was 5.9 million. The corresponding estimate of uncertainty was somewhat lower under the NE-model. A possible explanation for this is that uncertainty in the reproductive data was not properly represented in the comparison. Reducing the number of pup production estimates in the fitting had little effect on the point estimates, while it increased the standard deviation somewhat.

One difference between the models was in the future projections. The NE model suggests that the population will continue to increase under the current level of catches while the NW models suggest the population will level off. This is likely due to the fact that the NW Atlantic models assume that future reproductive rates will be similar to recently observed rates while the NE Atlantic model assume they will remain at the higher average level.

b) Comparison of NE model to a simple replacement yield model

Previous studies have shown that replacement yields are similar to sustainable yields estimated by the models used by WGHARP however, the model outputs have not been compared to simple replacement yield models.

c) Comparison of the NE model to the original model developed by Ultang (e.g., ICES CM 1992/Assess:5).

The current model has been developed from the Ultang model by the inclusion of uncertainty and the ability to estimate parameters. Therefore, the two models will perform identically if parameters are fixed.

2. Advice on model formulations – Sensitivity simulations

a) Run the NE model starting in the 20th century without the K assumption

The model presented in the 2003 assessment was modified during the previous meeting to eliminate the assumption about K. The current model does not include this assumption.

b) Run the NE model removing various data components

This was not considered worthwhile carrying out since the current data sets for the NE Atlantic harp seals are already limited.

c) Evaluate sensitivity to input parameters

This was addressed in the subgroup interessional report and continued at this meeting. The primary goal of the sensitivity analysis was to investigate how the model output, in terms of abundance, responds to changes in input parameters. In addition, it was also considered important to compare the prior and posterior distributions of the parameters. This applies to point estimates as well as dispersion measures like confidence intervals. In the model there are 4 parameters that are estimated: The mortality parameters M_0 and M_{1+}, the natality parameter, F, and the initial 1945 population size.

Except for the 1945 population, the initial prior means and standard deviations were determined after plenum discussions. The purpose of the priors are to reflect the subjective knowledge of the parameters with regard to accuracy reflected by the prior mean, and precision reflected by the prior standard

deviation. In the sensitivity analyses the priors were changed to see how the output responded.

To evaluate if the sensitivity was alarming or not, the change in 2005 abundance estimates with different priors were compared to the estimated standard deviation of these estimates. As a general conclusion the sensitivity analyses gave no alarming results. For the White Sea harp seal population the posteriors were close to the priors, while for the Greenland Sea harp seal population the prior mean was 0.07 for M_{1+} with a posterior mean of 0.08. The largest difference between prior and posterior was found for F in the Greenland Sea population, where the prior mean was 0.833 and the posterior was 0.64. When F was constrained to be close to 0.833 (by choosing a small prior standard deviation), the posterior means of M0 and M_{1+} increased substantially.

The analyses indicated that, while the modeled 1+ population size (N_{1+}) is sensitive to the biological input parameters, the ratio N_0/ N_{1+} is much less sensitive. Studies also showed that the mortality ratio M_0/ M_{1+} may exceed the value 5 which is the highest value previously considered by the working group.

d) Evaluate the importance of a valid age structure

This will be addressed during the development of a Bayesian version of the NW Atlantic model currently underway.

e) Track survival rates for realism

The age distribution predicted by the model for White Sea Harps was compared to age distribution on whelping grounds. Relatively close agreement was found for the period 1973-2000, while disagreement was found for the period 1959-1964. The latter was believed partly to be caused by problems with the ageing method/procedure used at the time. In conclusion, when using the age distribution as an indicator of survival rates, there is no indication that the model is biased for period of most interest to management.

f) Run the models with real and simulated data sets

The NE model has been run with all available data sets. Preliminary work has begun on running a Bayesian formulation of the NW Atlantic model with data from the Greenland Sea harp seals, but this work is not completed.

The NE model was investigated by simulations. The estimated pup productions were simulated as random and independent normal variates with a mean and uncertainty equal to the original abundance estimates. For each simulation, the parameters were estimated by the same procedure as for real data. 3D plots of the simulated parameter estimates for M_{1+}, M_0 and F revealed remarkably strong relationships between the 3 parameters for both harp seal populations. This indicates redundancy in the model and will be investigated further. Simulation studies will continue, and are expected to considerably improve the understanding of how the model works.

The subgroup will explore methods of developing a simulated data set for a hypothetical seal population to test the models prior to the next meeting.

g) Explore the feasibility of incorporating density dependence into the current models.

The subgroup will discuss the necessity and feasibility of incorporating density dependence into the models and report back to the Working Group at its next meeting.

4 HARP SEALS (Pagophilus groenlandicus)

4.1 Stock Identity, Distribution and Migration

Haug described the results of a recent study on the movements of adult harp seals tagged in the White Sea with satellite linked time depth recorders (Nordøy *et al*., this meeting, SEA-138). In late February 1995, 8 breeding female harp seals were tagged on the pack ice of the White Sea with 0.5 W satellite linked dive recorders (SLDR's) to study their distribution between breeding and moulting in May. In early May 1996 ten harp seals were tagged with 0.5 W SLDR's and released in the White Sea, to study distribution and dive behaviour after moulting in May. After moulting, all seals rapidly moved out of the White Sea, heading northwestwards into the Barents Sea. In July and August, the seals were dispersed along the pack ice edge, as well as in open water, between 5ºW and 87ºE , in periods reaching 82ºN. The proportion of days spent in open water increased from 40% in June to about 70% in September, decreasing to less than 20% in November, when new winter ice began to cover much of the Barents Sea. It is concluded that Barents Sea harp seals, within one yearly cycle, are distributed over vast areas, including parts of the Norwegian, Greenland and Kara Seas as well as all of the Barents Sea.

Satellite transmitters have also been deployed on harp seals in the NW Atlantic during the 1990s and again in 2004. Migration patterns were similar between two studies, and showed a northward migration primarily along the continental shelf into Davis Strait and Baffin Bay. A small proportion of seals went directly to the Greenland coast. The southward migration was similar. The results of this study will presented at the next meeting of the Working Group

No new data were available to suggest changes in our understanding of stock structure. Questions on the relationships between Greenland and White Sea stocks still exist, because these 2 groups do not separate well using genetics. A study of the movements of seals from Greenland Sea using satellite telemetry indicate there is some overlap in the Barents Sea during the summer, but not during the winter. However, this study was carried out only on adults, and should be repeated with juveniles.

Genetics analyses conducted at Memorial University of Newfoundland suggests that there is no clear MtDNA distinction between regions, and there is considerable overlap. Preliminary conclusions from this work are only that eastern seals separate from western seals.

More genetic material are available for DNA analyses, and it is recommended that these materials be analyzed for WGHARP's next meeting.

4.2 The Greenland Sea Stock

4.2.1 Information on recent catches and regulatory measures

For the Greenland Sea harp seals, the 2004 TAC was set at 15,000 1yr+ animals or an equivalent number of pups (where one 1yr+ animal should be balanced by 2 pups). WGHARP had identified the sustainable catch level (that would stabilise this population at present level) as 8 200, 1+ animals for 2004 and coming years. Available information on Norwegian catches of harp seals in the Greenland Sea pack-ice in 2004 and 2005 are listed in Appendix IV, Table 2. Russia has not participated since 1994. The total catches were 9,895 (including 8,288 pups) in 2004 and 5,808 (4,680 pups) in 2005. Removals were, respectively, 70% and 42% of the identified sustainable levels (Haug and Svetochev, this meeting, SEA-133).

4.2.2 Current Research

Other than the collection of material for the genetics study mentioned above (4.1), there was no new research described.

4.2.3 Biological parameters

There is no new information on biological parameters for this stock. There are, however, plans to examine age techniques, verification of age methods, and to validate and confirm method. Samples from known age animals are available.

4.2.4 Population assessments

Pup production

Results from the Norwegian survey of the Greenland Sea population are now in press (Haug *et al*. 2005). Pup production estimates are slightly different from those presented at the last meeting with a revised estimate of 98,500, SE=16,800 compared to 98,099, SE = 20,419. Earlier estimates of pup production are based on mark-recapture. The 2002 estimates are from an aerial survey.

Using the photographic counts obtained during the 2002 Greenland Sea harp seal survey (Haug *et al*. 2005), Salberg *et al*. (2005) modelled the expected seal density (or seal counts) in a whelping patch as a function of spatial position using a Generalized Additive Model. The number of pups counted from aerial photographs were distributed as negative binomial, but with different mean values. By using thin-plate smoothing splines, the GAM provided an estimate of the expected seal density at each spatial location in the patch. Changing the grid size used in the estimation procedure does not appear to affect the estimated pup production. However, the impact of the degrees of freedom and the initial distribution on the estimates must be explored further.

The estimates obtained from the spatial method were larger than those presented by Haug *et al*. (2005) but this was due to the methods used to account for pups between the photographs and the presence of open water. If similar assumptions are used, the 2 methods provide similar results.

Population model

The model used to assess the abundance and provide catch options for NE Atlantic harp and hooded seal populations at the last meeting (ICES CM 2004/ACFM:6) has been modified based upon recommendation from WGHARP. The major difference is that the model now estimates the biological parameters (M_{1+}, M_0 and pregnancy rates), rather using them as fixed input.

The population model estimates the current total population size using historical catch data and estimates of pup production. In principle, the model can also estimate biological parameters (M_{1+}, M_0 and F), but for the populations to which the model is applied there is not enough data to provide accurate estimates of M_{1+}, M_0 and F. To compensate for the lack of data, information from other similar populations are used as input to the model in the form of a prior distribution (mean and standard deviation) for each of M_{1+}, M_0 and F (see Table 3 for an example).

The same population dynamic model was used for both of the northeast Atlantic harp seal populations, but with stock specific values of prior distributions for M_0, M_{1+} and F. 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	=	Natality rate (i.e. proportion of mature females giving birth)

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

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

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:

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

.

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

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

The pup production is given as

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

where $0.5N_{i,t}$ is the number of females at age i.

The model calculates a few diagnostic quantities. These include the mean birth rate for 1+ females in year t is calculated as

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

and the depletion coefficient:

$$D_{1+} = \frac{N_{2015,1+}}{N_{2005,1+}}.$$

The estimated parameters are N_{1945} (the population size in 1945) along with the biological parameters M_{1+}, M_0 and F. These are found by minimizing an objective function consisting of the weighted (according to survey standard deviation) sum of squares of the differences

between the model value and the survey estimates of pup production. A penalty term resulting from the assumed (normal) priors on M_{1+}, M_0 and F is also added to the objective function. To minimize the total objective function the statistical software AD Model Builder (http://otter-rsch.com) is used. AD Model Builder calculates standard deviations for the model parameter, as well as the derived parameters such as present population size and D_{1+}.

Population estimates

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

Age at maturity ogive:

Table 1. Estimates of proportions of mature females (p) at ages 3-15. From Frie *et al.* (2003).

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

The prior distributions for M_{1+}, M_0 and F are given in Table 3 below. The prior for M_{1+} was based on the finding that previously used values for M_{1+} probably are too high (see section 4.3.3), and on comparison with harp seals in the north west Atlantic. The mean of the prior for M_0 was taken to be approximately three times that of M_{1+}.

Pup production estimates:

Table 2. Estimates of Greenland Sea harp seal pup production. From Øien and Øritsland (1995) and Haug *et al.* (2005).

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	98,500	.179

The estimated population is presented in Table 3.

Table 3. Estimated 2005 status of harp seals in the Greenland Sea. The column "Estimate" shows the estimated parameters (point estimate and standard deviations), while the column "Prior" shows the prior distributions placed on parameters. The rightmost part of the table gives the correlation matrix of the parameter estimates.

	ESTIMATE		PRIOR		CORRELATION[1]			
	Est.	SD	Mean	SD	M_{1+}	M0	F	N_{1+} (2005)
M_{1+}	0.09	0.013	0.08	0.015				
M_0	0.235	0.087	0.24	0.09	-0.17			
F	0.688	0.13	0.833	0.1666	0.59	0.29		
N_{1+}(2005)	634,960	107,070			-0.6	-0.5	-0.28	
N_0(2005)	106,710	17,878			-0.26	-0.1	0.44	0.72

[1] **The significance of these correlations is difficult to interpret. See Section 3 for more information on the relationships among these parameters obtained from the simulation studies.**

A 95% confidence interval for N_{1+}(2005) is 425,140 – 844,860. The current estimate is higher, but more uncertain, than the estimate obtained previously (348 800, 95% C.I. 318,000 –

379,000). These differences are primarily due to the change in the estimate of M_{1+} and the inclusion of additional sources of uncertainty in the parameters.

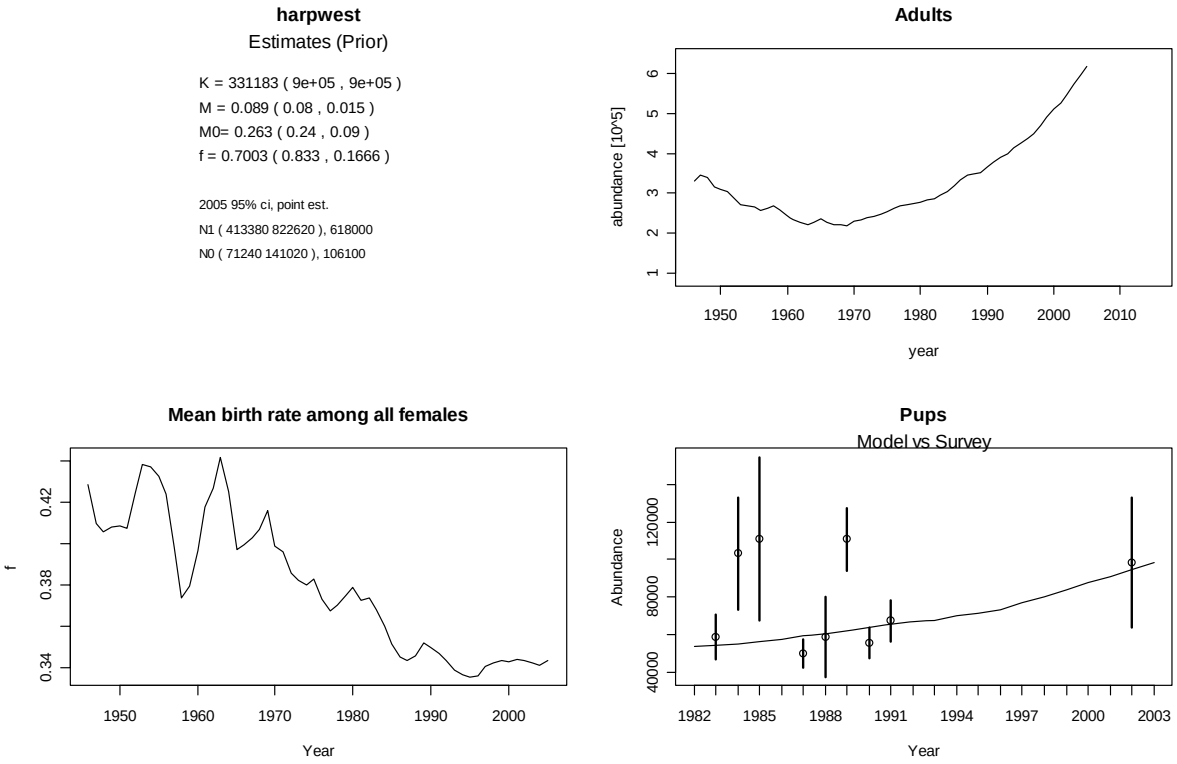

Figure 1 Fitted model and model diagnostics for harp seals in the Greenland Sea. Estimated N_{1+} population trajectory (panel labelled Adult). The lower-right panel shows 95% intervals (vertical bars) for available pup production estimates, and modelled pup production (solid line).

4.2.5 Catch Options

Options are given for three different catch scenarios:

1. Current catch level (average of the catches in the period 2001 – 2005)
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 under the estimated model. The catch options are further expanded using different proportions of pups and 1+ animals in the catches.

Table 4 Catch options with corresponding population trend (D_{1+}) for the next 10-year period for harp seals in the Greenland Sea.

OPTION #	CATCH LEVEL	PROPORTION OF 1+ IN CATCHES	PUP CATCH	1+ CATCH	D_{1+}		
PRIOR					Lower CI	point	Upper CI
1	Current	25.6% (current level)	3,303	1,138	1.18	1.51	1.83
2	Sustainable	25.6%	36,688	12,624	0.61	1.01	1.41
3	Sustainable	100%	0	31,194	0.66	1.05	1.44
4	2 X sust.	25.6%	73,376	25,248	0.00	0.45	0.97
5	2 X sust.	100%	0	62,388	0.058	0.55	1.03

These catch options are generally higher than those recommended in 2003 (ICES CM 2004/ACFM:6), but the confidence intervals for the depletion statistic D_{1+} are wider. The

reason is that the current estimate of M_{1+} is lower than the previously recommended M_{1+} which was fixed at 0.12. The background for the choice of the lower prior for current M_{1+} is outlined in section 4.3.3.

The current catch level (Options 1) will likely result in an increase in population size ($D_{1+}>1$). Catches 2X sustainable levels will result in the population declining by approximately 45-55% in the next 10 years. The 95% C.I. for D_{1+} under the sustainable catch options range from 0.6 – 1.4.

4.3 The White Sea and Barents Sea Stock

4.3.1 Information on recent catches and regulatory measures

The 2004 TAC set for harp seals in the Barents Sea and White Sea was set at the sustainable level estimated by WGHARP (45,100 1yr+ animals or an equivalent number of pups where one 1yr+ animal is equivalent to 2.5 pups). Norway was allocated a quota of 10,000 1yr+ animals (with a similar equivalence between 1yr+ animals and pups). Recent Russian and Norwegian catches of harp seals in the White and Barents Sea are listed in Appendix IV, Table 3. The traditional Russian helicopter catch of harp seals could not be conducted in the White Sea in 2004. Difficult ice conditions and increased operational costs for the helicopters contributed to this. A new (for sealing) resource tariff was also imposed upon the sealing activities. Because no Norwegian vessels operated in the southeastern Barents Sea in 2004, the total removal from this stock in 2004 was 33 1+ animals taken for scientific purposes in the northern Barents Sea. The combined catches for 2005 were 22,474 (including 15,420 pups), which is 29% of the sustainable yields recommended by WGHARP in 2003 for this stock (Haug and Svetochev, this meeting, SEA-133).

Only a few animals were caught in Norwegian gill net fisheries in 2004 and 2005 (Appendix IV, Table 6).

4.3.2 Current Research

Deployments of satellite transmitters on post-moult White Sea animals are planned with the intention to start with young animals and observe the ontogeny of their movements and diving as they mature. This is planned for a 5 yr period, with about 15 deployments per year and will be linked to a study of ice conditions.

Ecological studies of harp seals in the Barents Sea during summer are currently underway.

4.3.3 Biological Parameters

Korzhev presented his analysis of the uncertainty in the White Sea population estimate. Current models use a fixed harp seal population natural mortality rates of $M_{1+} = 0.1$ for all the age groups. Korzhev (this meeting, SEA-141) considers a model in which instantaneous natural mortality rates varying with age. The objective of this paper was to examine how mortality rates varied with age. The von Bertalanffy equation is needed to calculate a_1, k_1, and b, which are then fed into a generalized mortality equation derived from cod. The model provides a conceptual relationship of harp seal natural mortality with the age at maturity and theoretical limit age of seals and, in the non-evident view, with linear and weight growth. On the basis of these observations linear and weight growth parameters were estimated and natural mortality rates of harp seals up to age 30+. Dependence of variation of natural mortality rates on age at maturity and theoretical limit age of harp seals is shown. .

Korzhev (this meeting, SEA-142) next presented his modelling of the White sea harp seal populations dynamics with regard to uncertainties in parameter estimates of natural mortality and birth rates. Closer correspondence of modelled values to the actual data were obtained

under the average values of natural mortality M_{1+} equalled to 0.7, 0.8 and 0.9. With values of M_{1+} greater than 0.9, the modelled and observed values of pup abundance were significantly different. The target function estimates were obtained using a small amount of observations (by only four points) and, therefore, the statistical estimates are not reliable. It is necessary to repeat these analyses with the data from seal surveys in 2004 and 2005, as well as to use biological theory to narrow the range of the birth rate variation.

These two working papers underlined that mortality rates are not constant across all age classes. They also indicated that the fixed rates used in earlier meetings (0.10 to 0.12; ICES CM 2004/ACFM:6), may have been too high. Mortality rates might be more in the range of 0.07, to 0.09. M_{1+} estimated in the NW Atlantic is lower, approximately 0.05-0.06, but this is partly a function of the model structure which has 25 year classes, instead of 20 year classes which was used in the NE Atlantic model. Also, in the NW Atlantic corrections for non-reporting of catches and bycatch are incorporated into the model. This would have the effect of lowering the calculated 'natural' mortality parameter. The NW Atlantic value could be used as a lower value, but need to identify a range or level of variability. Previous NE models use a constant mortality rate for 1+ and a fixed rate of 3 or 5 x M_{1+} for pups.

4.3.4 Population Assessment

Pup Production

Results from pup survey flown on 23 March 2004 were presented by Golikov (this meeting, SEA-134). Based upon reading of digital photographs, pup production estimates were 231,812 (SE=44,000). Counts were lower than previous years perhaps because the survey was flown later than in previous years (animals may have dispersed, entered water). The survey was completed later than had been recommended previously. Some patches may also have been missed.

Zabavnikov (Egorov *et al*., this meeting, SEA-143) presented a description of the survey methods used in the March 2004 White Sea multispectral pup survey. Surveys actually flown over several days 16-23 March, with relatively complete surveys conducted on 22 and 23 March. Counts in 2004 were slightly lower than in previous years. Due to minor problems with the aircraft, surveys were being flown slightly later than in previous years and therefore, animals may have dispersed. Due to heavier ice conditions and the fact that animals were more dispersed than in previous years, some groups may have been missed. Size distribution of animals measured on digital imagery was quite different from previous surveys and there was an absence of younger animals in the sample. These size distribution data also offer opportunities for additional research. A third possible reason for fewer pups may be that females did not return to the whelping patch due to poor condition. However, insufficient data are available to determine their condition in 2004. Pup production on 23 March was estimated at 234,000 (SE=48,000).

There were differences in estimates presented in the two papers SEA-143 (234,000 ±48,000) and SEA-134 (231,812 ±44,000). These minor differences indicate that similar estimates can be obtained from digital photography and multispectral surveys.

WGHARP was sufficiently concerned about biases resulting from the late and incomplete coverage on the 23 March surveys, that they recommended that the 2004 estimate not be used. It was suggested that the time series up to 2003 be used in the assessment, and then wait for the 2005 estimates, which was flown earlier and covered the whole area. The WG's feeling was that the earlier timing of the 2005 survey would make the data less biased.

Population estimates

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

Age at maturity ogive:

Table 5. Estimates of proportions of mature females (p) at ages 5-11. From Frie *et al.* (2003).

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

The prior distributions for M_{1+}, M_0 and F are given in Table 7 below. The basis for the choice prior for M_{1+} was the same as in the Greenland Sea (see section 4.2.4). The mean of the prior for M_0 was taken to be approximately five times that of M_{1+}. The prior on F is based on Kjellqwist *et al*. (1995).

Pup production estimates:

Table 6 Estimates of Barents Sea / White Sea harp seal pup production (ICES CM 2004/ACFM:6; Potelov *et al.* 2003; Egorov *et al.*, this meeting, SEA-143).

YEAR	POINT ESTIMATE	C.V.
1998	286,260	.073
2000	322,474	.089
2000	339,710	.095
2002	330,000	.103
2003	327,000	.125

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.

Table 7 Estimated 2005 status of harp seals in the Barents Sea / White Sea. The column "Estimate" shows the estimated parameters (point estimate and standard deviations), while the column "Prior" shows the prior distributions placed on parameters. The right-most part of the table gives the correlation matrix of the parameter estimates.

	ESTIMATES		PRIOR		CORRELATION[1]			
	Est	SD	Mean	SD.1	M1+	M0	F	N1+(2005)
M1+	0.08	0.013	0.08	0.015				
M0	0.40	0.144	0.4	0.15	-0.14			
F	0.838	0.157	0.84	0.168	0.19	0.11		
N1+(2005)	2,064,600	290,040			-0.36	-0.74	-0.52	
N0(2005)	360,880	31,775			-0.52	-0.29	0.4	0.46

[1] The significance of these correlations is difficult to interpret. See Section 3 for more information on the relationships among these parameters obtained from the simulation studies.

A 95% confidence interval for $N_{1+}(2005)$ is 1,496,520 – 2,633,480. The current estimate is higher, but more uncertain, than the estimate obtained previously (1,829,000, 95% C.I. 1,651,000 – 2,007,000). These differences are primarily due to the change in the estimate of M_{1+} and the inclusion of additional sources of uncertainty in the parameter.

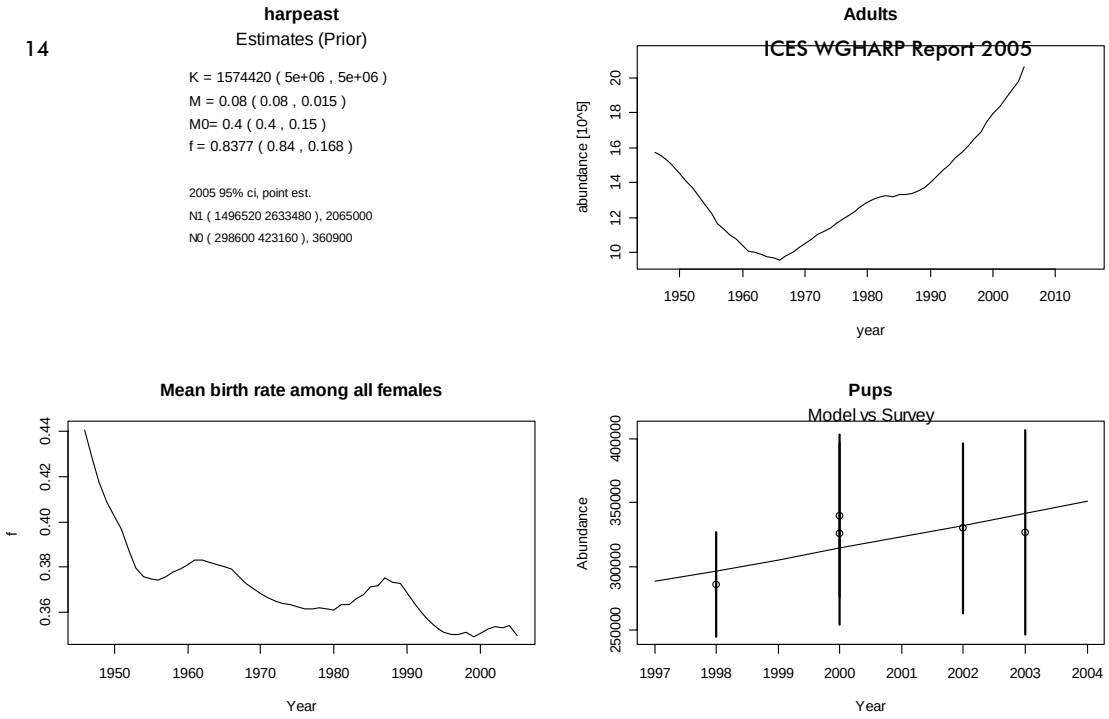

Figure 2 Fitted model and model diagnostics for harp seals in the Barents Sea / White Sea. Estimated N_{1+} population trajectory (panel labelled Adult). The lower-right panel shows 95% intervals (vertical bars) for available pup production estimates, and modelled pup production (solid line)

4.3.5 Catch Options

Previously, catch options have been given separately under the assumptions $M_o = 3M_{1+}$ and $M_o = 5M_{1+}$. Since, M_{1+} and M_0 now are estimated, only one set of catch option is given.

Table 8 Catch options with corresponding population trend (D1+) for the next 10-year period for harp seals in the White Sea / Barents Sea.

OPTION #	CATCH LEVEL	PROPORTION OF 1+ IN CATCHES	PUP CATCH	1+ CATCH	D_{1+}		
PRIOR					Lower CI	Point	Upper CI
1	Current	11.5% (current level)	25,945	3,371	***0.91***	***1.35***	***1.78***
2	Sustainable	11.5%	153,878	19,995	***0.57***	***0.98***	***1.39***
3	Sustainable	100%	0	78,198	***0.62***	***1.04***	***1.50***
4	2 X sust.	11.5%	307 ,56	39,990	***0.12***	***0.53***	***0.93***
5	2 X sust.	100%	0	156,396	***0.24***	***0.67***	***1.10***

These catch options are higher than those recommended in 2003 (ICES CM 2004/ACFM:6), but the confidence intervals for the depletion statistic D_{1+} are wider. The reason is that the current estimate of M_{1+} is lower than the previously recommended M_{1+} which was fixed at 0.09 ($M_o = 5M_{1+}$). The background for the choice of the lower prior for current M_{1+} is outlined in section 4.3.3. It has been noted that the model is sensitive to the choice of prior for M_{1+}, and that the population size (and hence the sustainable catches) are inversely related to M_{1+}.

The current catch level (Options 1) will likely result in an increase in population size ($D_{1+}>1$). Catches 2X sustainable levels will result in the population declining by approximately 50-67% in the next 10 years. The 95% C.I. for D_{1+} under the sustainable catch options range from ~0.6 – 1.4.

4.4 The Northwest Atlantic Stock

4.4.1 Information on recent catches and regulatory measures

Stenson reviewed estimates of human induced mortality in NW Atlantic harp seals during 1952-2004 (this meetiing, SEA-140). Three sources of mortality were accounted for—reported catches (commercial and subsistence), struck and loss, and bycatch (Sjare *et al*., this meeting, SEA-135). Commercial and subsistence hunts account for the majority of the removals. Takes are summarized in Appendix IV, Table 10.

Between 1952 and 1971, catches taken in the Canadian commercial hunt averaged in excess of 288,000 seals. Between the introduction of quotas in 1972 and the demise of the large vessel hunt in 1982, an average of 165,000 seals was taken annually. Catches decreased after 1982 and remained low, averaging approximately 52,000, until 1995. Annual catches, consisting primarily of young of the year, increased to an average of 258,000 between 1996 and 2004. The age composition of catches at the Front and in the Gulf were estimated based on reported numbers of pups taken and biological sampling of seals one year of age and older (1+) taken from the commercial harvest and research samples. Prior to 1980, catches in Greenland were consistently less than 20,000 animals. Since 1980 Greenland catches increased relatively steadily to a peak of over 100,000 in 2000. In recent years, catches have declined to just fewer than 70,000. The reason for this decline is unclear, but could be due to either a change in distribution or localized abundance. Estimates of the age composition of seals harvested in Greenland were obtained from biological samples collected in West Greenland between 1970 and 1993. Although limited data are available on catches in the Canadian Arctic, they appear to be relatively low (generally <5,000). A recent study indicates that current catches average less than 1,000 per year Appendix IV, Table 11).

In 1999 the National Marine Mammal Peer Review Committee reviewed the available information the proportion of seals that are killed but not recovered. They concluded that specifically accounting for mortalities associated with struck and lost is more informative than including them as part of an aggregate natural mortality. However, there are limited data on which to base estimates, particularly in northern areas. The same committee reviewed additional data and agreed that the level recommended previously be retained. Based on these recommendations, it is assumed that losses are 1% for young of the year seals killed in southern Canadian waters prior to the end of the large vessel hunt in 1982 and 5% for first year animals after this white coat hunt ended. The loss rate for seals one year of age and older taken in southern Canadian waters and all seals taken in Greenland or the Canadian Arctic is assumed to be 50%.

Estimates of harp seal bycatch in the Newfoundland lumpfish fishery increased from less than 1,000 in the early 1970s to 46,400 in 1994. By 2003, the bycatch had declined to approximately 5,000. Low numbers of harp seals (<1,000) are also caught in US fisheries.

The average total removal from 1952 – 1982 was approximately 388,000, but declined to 178,000 per year between 1983 and 1995. Since 1996, higher catches in Canada and Greenland resulted in average annual removals of 471,000. Young of the year account for approximately 68% of the current removals. Appropriate methods of incorporating uncertainty into these estimates of total removals and age structure should be developed.

4.4.2 Current research

Stenson summarized recent data from the Atlantic Seal Research Project on at-sea tracking of harp seal movements. Results of tracking 19 animals released off of NFLD were similar to the observations from 21 deployments in the 1990s. Most animals followed the Labrador coast northward and then dispersed into Baffin Bay, Davis Strait, and west coast of Greenland. A very

few animals dispersed eastward to the east coast of Greenland, as in the 1990's deployment. Some double migrations occurred.

Similar work is occurring the Gulf of St. Lawrence.

A seal-salmon fisheries interaction study was initiated in Newfoundland and Labrador.

Results will be presented at a later WGHARP meeting for all of the preceding.

4.4.3 Biological parameters

Sjare presented an update of data on Northwest Atlantic harp seals (Sjare and Stenson, this meeting, SEA-136, Sjare *et al*. 2004). Estimates of the total number of harp seals in the Northwest Atlantic declined from approximately 3.0 million in the 1950s to 1.8 million in the early 1970s and then increased steadily to 5.2 million in 1996 where it has since stabilized. During this period, annual fertility rates increased from approximately 86% in the 1950s to a high of 98% in the mid 1960s and then declined steadily to approximately 65-70% by the early 1990s where it has stabilized. The fertility rate was 52% and 66% for 2002 and 2003 respectively. Concurrently, the mean age of sexual maturity decreased from 5.8 years in the mid 1950s to 4.1 in the early 1980s, then increased to 5.3 years by the early 1990s and peaked at 5.7 years by 1995. These changes appear to have occurred in a step-like pattern. From 2001-2003 the mean of maturity was approximately 5.3 years. Mean age of sexual maturity was similar, if not somewhat lower on average, to mean ages from the Greenland and Barents Sea harp seal populations. There were no new data on ovulation rates available.

Although the direction of change in each of the reproductive parameters examined was generally consistent with a density dependent response, changes in population size explained very little of the variability observed in ovulation rates and mean age of sexual maturity. There are issues with small sample sizes and hunter biases, and the assumption that all adult females migrate to the whelping grounds. However, these findings remain consistent with the concept that ecological factors (e.g., fluctuating prey availability) may be important in explaining long-term trends in reproductive parameters.

4.4.4 Population Assessment

Stenson presented the results of the 2004 pup production surveys for harp seals in the Northwest Atlantic (Stenson *et al*. 2005). Photographic and visual aerial surveys to determine current pup production of northwest Atlantic harp seals were conducted off Newfoundland and Labrador (the "Front"), and in the Gulf of St. Lawrence during March 2004. Surveys of four whelping concentrations were conducted between 5 and 18 March resulting in estimated pup production of 640,800 (SE=46,900, CV=7.3%) at the Front, 89,600 (SE=22,500, CV=25.4%) in the northern Gulf, and 261,000 (SE=25,700, CV=9.8%) in the southern Gulf (Magdalen Island), for a total of 991,400 (SE=58,200, CV=5.9%). Surveys were corrected for the temporal distribution of births and the mis-identification of pups by readers. Comparison with previous estimates indicates that pup production has not changed since 1999, likely due to the increased hunting of young animals which began in the mid 1990s.

Hammill presented the most recent estimate of total population abundance for Northwest Atlantic harp seals (Hammill and Stenson, thios meeting, SEA-139). A population model, incorporating uncertainty in reproductive rates, was constructed to examine changes in the size of the Northwest Atlantic harp seal population between 1960 and 2005. The model incorporated information on reproductive rates, reported removals, as well as estimates of non-reported removals and losses through bycatch in other fisheries to determine the population trajectory. The model, with 25 age classes, was fit to survey estimates of pup production by adjusting the initial total population size (1960) and estimates of adult

mortality. Age-0 mortality was fixed at three times age 1+ mortality rates. The model also includes a year-specific parameter to incorporate potential high pup mortality events. The northwest Atlantic harp seal population is currently estimated to number ~ 5 .9 million animals (SE=747,000), which is similar to the previous abundance estimate.

Future work will address variability in the starting population size and mortality rates.

4.4.5 Catch options

The sustainable yield estimated from the model presented (Hammill and Stenson, this meeting, SEA-139) for the Northwest Atlantic harp seal population is 554,000 animals. If it is assumed that the current level and age structure of catches in the Canadian Arctic and Greenland, and as bycatch in commercial fisheries remain the same, this would equate to a landed catch of 325,000 at the Front and Gulf.

5 Hooded seals (Cystophora cristata)

5.1 Stock Identify, Distribution and Migration

Stenson presented data on the seasonal distribution and diving behaviour of hooded seals on the Grand Banks and Flemish Cap. Thirty-nine hooded seals were instrumented during 1994-2004 near Newfoundland and Greenland. In 1994, all females foraged over the Flemish Cap with males dispersing elsewhere. In March 2004, none of the animals foraged on the Flemish Cap. Then in July 2004, six animals were tagged off the east coast of Greenland. Three returned to the Newfoundland breeding grounds, but none foraged over Flemish Cap. An additional 16 tags were deployed in July-August 2005, and the animals are being tracked.

5.2 The Greenland Sea Stock

5.2.1 Information on recent catches and regulatory measures

A summary of recent catches of the Greenland Sea stock of hooded seals is provided in Appendix IV, Table 1 (Haug and Svetochev, this meeting, SEA-133). The 2004 TAC for this stock was 5,600 1yr+ animals or an equivalent number of pups. If a harvest scenario included both 1yr+ animals and pups, one 1yr+ animal should be balanced by 1.5 pups. In 2003, WGHARP identified the sustainable catch level that would stabilize the hooded seal population at present level, as 5 600 animals for 2004 and coming years. Total catches (all taken by Norway as Russian sealers did not operate in the Greenland Sea in the period) were 4,881 (including 4,217 pups) in 2004 and 3,752 (3,633 pups) in 2005. This was 87% and 67% of the identified sustainable yields, respectively.

5.2.2 Current research

Haug summarized the results of aerial and vessel surveys of hooded seal pup production in the Greenland Sea pack-ice during the March 2005 whelping season (Haug and Nilssen, this meeting, SEA-137; Salberg *et al.*, this meeting, SEA-144). Two fixed-wing twin-engine aircraft were used for reconnaissance flights and photographic surveys along transects over the whelping patches. A helicopter assisted in the reconnaissance flights, and subsequently flew combined visual/video transect surveys over the whelping patches. The helicopter was also used for other purposes, such as monitoring the drift of ice and patches, age-staging (also performed along transects over the patches) of the pups, and assessing the fidelity of pups to their natal ice pans. A total of 15 reconnaissance surveys were flown to survey the entire area along the eastern ice edge between 67°25’ and 75°00’N, and may have been the best reconnaissance conducted to date. Repeated systematic east-west transects spaced 5 or 10 nm

apart were flown from the eastern ice edge, with spacing expanding to 10-20 nm (sometimes longer) over the drift ice to the west.

Three hooded seal breeding patches were located and surveyed visually and photographically on 24 March. A total of 39 photo transects were flown at a spacing on 1 nm at an altitude of about 200 m; 979 photos were shot in the three observed whelping patches (A, B, and C) in the area between 71º 09' – 71º 54'N and 15º 23' – 17º 54'W. Few whelping hooded seals and pups were observed outside the three whelping patches surveyed. The results from the aerial surveys will be used to estimate the 2005 hooded seal pup production, and will be available for the 2006 WGHARP meeting. Preliminary results suggest that pup production in 2005 may be lower than observed in the previous survey (1997).

5.2.3 Biological parameters

No new information on biological parameters for this stock was presented. However, there are reproductive materials available to Russian researchers that could provide valuable data to future assessments of this stock. WGHARP requests that these data be analyzed and presented at the spring 2006 meeting.

5.2.4 Information on the state of the stock

No new information on the status of this stock was presented. Results from the pup production survey conducted in 2005 will be available in spring 2006.

5.3 The Northwest Atlantic Stock

5.3.1 Information on recent catches and regulatory measures

Catches are shown in Appendix IV, Table 12. Canadian catches have been quite low since 1999 (~150 animals per year) with the take in 2004 increasing to around 400 animals. There is an annual quota of 10,000 age 1+ animals in Canada. Bycatch was very limited due to the species being distributed away from commercial fisheries.

Catches in Greenland have been in the 6,000-7,000 range during 1970-2001, but had declined to around 3,500 in 2002.

5.3.2 Current research

A hooded seal pup survey was conducted in 2005 in the Gulf, Front, and the Davis Strait. The surveys included visual and photographic estimates at the Front, and visual elsewhere. When completed, these results will provide an updated estimate of hooded seal abundance in the Northwest Atlantic by spring 2006.

Recent satellite telemetry studies were discussed in Section 5.1 of this report. Diet studies for hooded seals should be ready for discussion by spring 2006. Analyses of hooded seal genetic samples collected from all whelping areas for all putative stocks (NW Atlantic thorough the Greenland Sea) have been collected and are currently being analyzed. A graduate student is currently analyzing all the available reproductive data and should have results ready for the next WGHARP meeting.

5.3.3 Biological parameters

No new information on biological parameters for this stock was presented.

5.3.4 Information on the state of the stock

No new information on the status of this stock was presented. Results from the pup production survey conducted in March 2005 will be available in spring 2006.

6 On the Implementation of Biological Reference Points for Harp and Hooded Seals

During the Joint ICES/NAFO Working Group on Harp and Hooded Seals(WGHARP) meeting in Archangelsk in September 2003, WGHARP discussed the establishment of biological reference points for harp and hooded seals. A conceptual framework for applying the precautionary approach to Atlantic seal management, developed primarily to fit the management of northwest Atlantic harp seals, was outlined and discussed. The group agreed that this multi-tier framework could be a way forward to establish biological reference points (BRP) for other harp and hooded seal populations. It was agreed that if ACFM found the approach useful and acceptable, a WGHARP subgroup (Haug, Filin, Hammill, Merrick and Stenson) would collaborate via correspondence to further develop ways to apply the PA to providing advice for harp and hooded seals.

ACFM accepted the approach proposed by WGHARP and gave them the green light to further define BRPs, if possible, for the different harp and hooded seal populations. However, there is one important correction to be made to the ACFM response: ACFM defined the N_{70} (70%) level as a target reference point. This is not correct – the N_{70} level is meant to be a first precautionary reference point. When the population is between N_{70} and N_{max}, managers are virtually free to set harvest levels that may stabilise, reduce or increase the population, so long as the population remains above the N_{70} level. When a population falls below the N_{70} level, conservation objectives are required to allow the population to recover to above the precautionary (N_{70}) reference level. N_{50} is a second precautionary reference point where more strict control rules must be implemented, whereas the N_{30} reference point is the ultimate limit point at which all harvest must be stopped.

Results from the inter-sessional work by correspondence of a WGHARP subgroup can be found in ICES CM 2005/ACFM:06. The full WGHARP discussed the work at the 2005 meeting in St. Johns, Newfoundland, and generally supported the finds in the report. Discussion during the meeting further refined the recommendations of the WG.

6.1 Definition of Data Rich versus Data Poor Stocks

WGHARP recommends that data rich stocks should have data available for estimating abundance with the following characteristics:

1. Accuracy of the data
    a. Precision—abundance estimates should have a Coefficient of Variation about the estimate of #30%
    b. Abundance estimates should be unbiased
2. The most recent abundance estimates should be prepared from surveys and supporting data (e.g., birth and mortality estimates) that are no more than 5 years old[1]
3. A time series of at least three abundance estimates should be available spanning a period of 10-15 years with surveys separated by 2-5 years

Stocks whose abundance estimates do not meet all these criteria are considered data poor.

1 Surveys and associated data that are 8+ years old are too old to be considered as recent data (due to increasing imprecision as the data age). Therefore, a stock whose last abundance estimate is more than 8 years old, would not be considered to have a recent abundance estimate and would therefore, be considered data poor.

6.2 Definitions of Biological Reference Points

For data rich stocks, there is always an N_{max}, and this value can be applied to the percentages proposed by WGHARP to define the reference points—70% of N_{max} (first precautionary RP), 50% of N_{max} (second precautionary RP) and 30% of N_{max} (limit RP or N_{lim}). See **Figure 3** for an example of this multi-tier system. The WG agrees that these values could be appropriate for other seal populations.

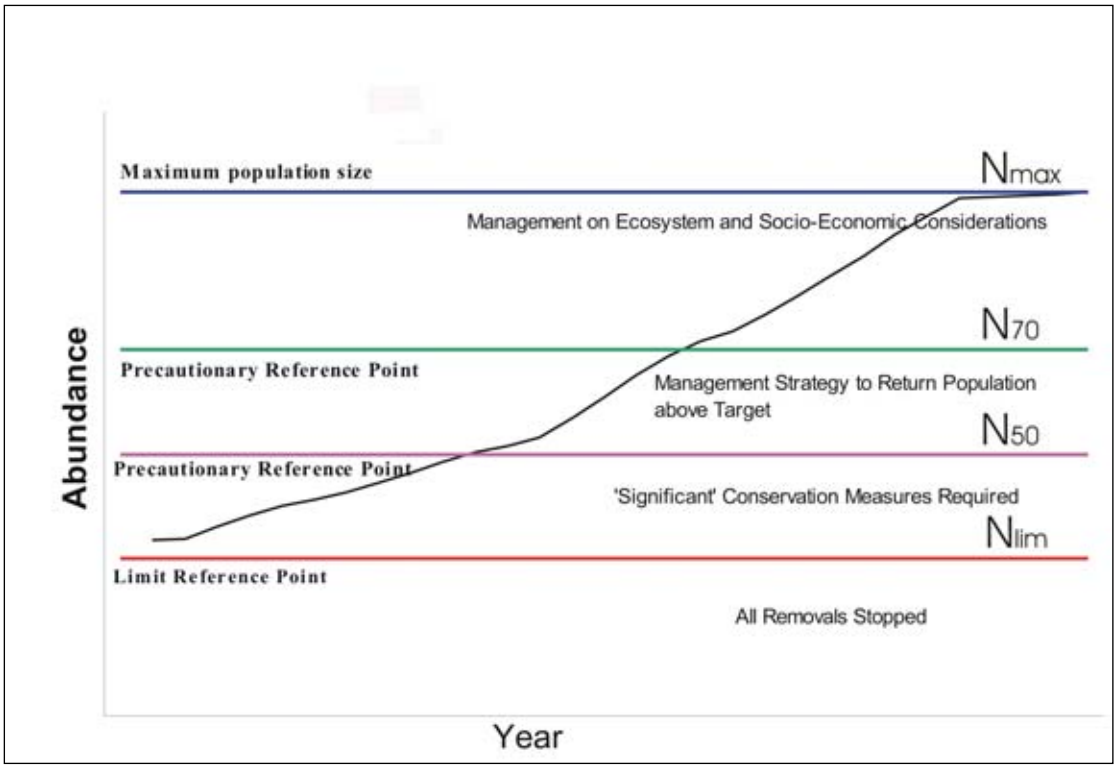

Figure 3. Reference points for a data rich stock.

For data poor stocks, it is recommended that only the lower tier (below N_{lim}) be defined. In this case, the four tiers effectively collapse to two (i.e., above and below N_{lim}; **Figure 4**).

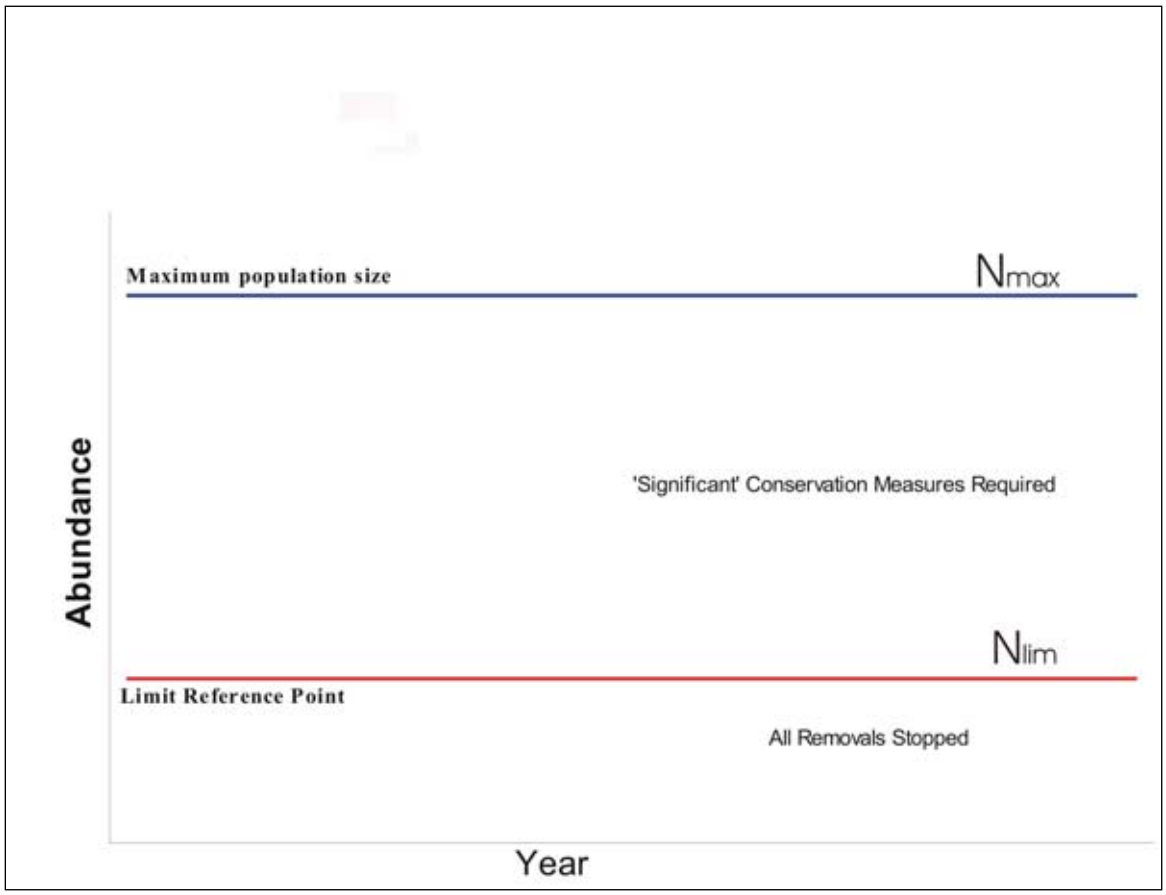

Figure 4. Reference points for a data poor species.

The data rich versus poor distinction is significant to setting values for the WGHARP's proposed multi-tier approach to biological reference points:

1. For data rich stocks –

   h) All tiers would generally be referenced to N_{max}, which is recommended to be the highest accurate historical estimate of total population abundance

   i) In the case of a data rich stock with no accurate historical population estimates, N_{max} would be set to the highest recent accurate population estimate

2. For data poor stocks –

   a) If an accurate historical abundance estimate is available which is greater than the recent estimate, then that number would be used as N_{max} and then to set N_{lim}

   b) If no accurate historical abundance estimate is available, then N_{max} cannot be defined but N_{lim} can be independently defined using the IUCN criteria for "vulnerable."

WGHARP recommends that the limit reference point (N_{lim}) could be either 30% of the historical accurate population estimates or should be set independently using IUCNs vulnerable criteria. This is the point where COSEWIC would consider listing the species as threatened under the Canadian Species At Risk Act (SARA; www.sararegistry.gc.ca).

However, N_{lim} may not conform to any threshold value under the US Endangered Species Act (www.nmfs.noaa.gov/prot_res/). N_{70} equates with the point where Canada would list the species as of special concern under SARA, and in the US would be considered depleted under its Marine Mammal Protection Act (www.nmfs.noaa.gov/prot_res/overview/mm.html).

6.3 Reference Point Based Harvest Control Rules

Finally, WGHARP proposes the following control rules to determine which assessment approach to follow:

1. For data poor stocks

   a) If stock has no recent, accurate abundance estimates, then no harvest should occur.

   b) If stock has 1-2 recent, accurate abundance estimates, then the control rules collapse to the point where the only concern is whether the abundance is less than or greater than N_{lim}, such that:

      i. If abundance is greater than N_{lim}, then the PBR protocol is used to set the TAC

      ii. If abundance is less than N_{lim}, then no harvest should occur

2. For data rich stocks, that is the stock has 3 or more recent, accurate abundance, estimates then the full set of control rules established under the multi-tier system would apply. For example,

   a) If abundance is greater than N_{70}, management objectives would be based upon the appropriate WGHARP model and would require that the population remain above the N_{70} level.

   b) If the abundance is greater than N_{50}, the management objective must include efforts to conserve the population (i.e. projections of proposed management actions must have a >0.8 probability of the population returning to N_{70} within 10 years)

   c) If abundance is greater than N_{lim}, and less than $N_{50,}$ then significant conservation measures will be required (i.e. a 95% chance of recovery would be required leading to something like the PBR protocol for setting harvest levels)

   d) If the abundance is less than N_{lim}, then no harvest should occur

The Working Group considered the 5 stocks of harp and hooded seals in the North Atlantic. They agreed that based upon the criteria outlined above, the NW Atlantic and Greenland Sea hooded seal stocks should be considered data poor. The NW Atlantic harp seal stock is considered to be data rich. Although reproductive data for the Greenland Sea stock needs to be updated, there are sufficient pup production estimates to consider this stock data rich. There have been 5 accurate pup production surveys since 1998 in the White Sea. The quality of the pup surveys are sufficient to consider the stock data rich. However, as for the Greenland Sea, reproductive data for this stock is not current. Recent reproductive data are required for both of these stocks to maintain these classification

7 Advice for ACFM and NAFO

The Chair of the Working Group, with assistance from Stenson, will prepare the draft advice for ICES and NAFO based on the results of this meeting circulate this to the Working Group for their review.

8 Recommendations for Chairman

The WG recommends that ACFM consider Dr. Richard Merrick (USA) be appointed as the next Chair of WGHARP

9 Future Activities of the Working Group

The Working Group agrees that it would be beneficial to meet in 2006 to address issues that were raised at the current meeting. It also noted that a number of studies related to hooded seals will be competed in the coming year. Therefore, the WG **recommends** that all available data on hooded seals be analysed and presented at the next meeting. The possibility of organizing a workshop or symposium devoted to current research on hooded seals should also be considered. The 2006 meeting is tentatively scheduled for June at the ICES Headquarters in Copenhagen, Denmark.

The modelling subgroup agreed to continue their work via correspondence. Evans (Canada) and Salberg (Norway) have agreed to join the subgroup. Future work of the modelling group will include:

1. Exploring the usefulness and feasibility of incorporating density dependence into the models used by WGHARP.
2. Developing fully Bayesian analysis models
3. Exploring the relationship between M_{1+} and M_0
4. Examine the feasibility of estimating mortalities from pup production estimates.

The results of these studies will be presented at the next meeting of WGHARP. :

The subgroup on Biological Reference Points will also continue to work via correspondence. The primary goal of this subgroup will be to estimate the reference points for the White Sea/Barents Sea and Greenland Sea harp seal populations based upon the approaches decided upon at this meeting and approved by ACFM.

10 Recommendations

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

1) All available data on stock identity, biological parameters and abundance of hooded seals be analysed and presented to the Working Group at the next meeting.

2) Surveys of abundance must be completed at regular intervals (i.e. every 5 years or less) for all stocks of harp and hooded seals, and research efforts between survey years should be focused on:

   i) 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.
   ii) Improving survey techniques among areas, and
   iii) Collection of relevant biological data required for population assessments.

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

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

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

6) Efforts to improve and standardize methods for age determination in harp and hooded seals should be initiated.

11 Other business

There was no other new business presented

12 Adoption of the Report

The report was adopted by the Working Group at 1640 Newfoundland Daylight Time, 3 September 2005.

Annex 1: PARTICIPANTS

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Annex 2: 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 report and recommendations from the intersessional modelling subgroup

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
- 4.2.3 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 Population assessment
- 4.4.5 Catch options

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 Information on the state of the stock

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. Review report and recommendations from the intersessional subgroup dealing with the possible implementation of Biological Reference points for harp and hooded seals

7. Draft advice for ACFM / NAFO

8. Recommendations for Chairman

9. Future activities of the Working Group

10. Recommendations

11. Other Business

12. Adoption of Report

Annex 3: REFERENCES

I. Working Documents Presented at the Meeting

SEA No.	Section	Title
133	4.2.1, 4.3.1, 5.2.1	Haug, T. and V. Svetochev 2005. Norwegian and Russian catches of harp and hooded seals in the Greenland Sea and in the Barents Sea/White Sea in 2004-2005.
134	4.3.4	Golikov, A. 2005. About estimation of harp seal (*Pagophilus groenlandicus*) pup production in the White Sea in 2004.
135	4.4.1	Sjare, B., D. Walsh, S. Benjamins and G. B. Stenson. 2005. An update on harp seal by-catch estimates in the Newfoundland lumpfish fishery.
136	4.4.3	Sjare, B. and G. B. Stenson. 2005. Updating reproductive parameters of female harp seals (*Pagophilus groenlandicus*) in the Northwest Atlantic: 2002-2003.
137	5.2.2	Haug, T. and K. T. Nilssen. 2005. Report form surveys of hooded seal pup production in the Greenland Sea pack-ice during the 2005 whelping season.
138	4.1, 4.3.2	Nordøy, E. S., L. P. Folkow, V. Potelov, V. Prichemickhine and A. S. Blix. 2005. Distribution and dive behaviour of Barents Sea harp seals.
139	4.4.4	Hammill, M. O. and G. B. Stenson. 2005. Abundance of northwest Atlantic harp seals.
140	4.4.1	Stenson, G. B. 2005. Estimates of human induced mortality in northwest Atlantic harp seals, 1952-2004.
141	4.3.3	Korzhev, V. A. 2005. Estimation of natural mortality rates of harp seals from the White Sea population.
142	4.3.4	Korzhev, V. A. 2005. Modeling of the White Sea harp seal population abundance dynamics with regard to uncertainties in estimation of the population parameters.
143	4.3.4	Egorov, S. A., I. N. Shafikov, V. A. Tereshchenko and V. B. Zabavnookov. 2005. Distribution and estimation of harp seal (Phoca groenlandica) pups numbers in the White Sea population on whelping patches in 2004 and dynamics it on data of multispectral air surveys.
144	5.2.2	Salberg, A.-B., T. Haug and K. T. Nilssen. 2005. Estimation of hooded seal pup production in the Greenland Sea in 2005: Preliminary results of photographic counts.

145	3	Skaug, H. 2005. Comparison of NE and NW models
146	3	Harbitz, A. and A.-B. Salberg. 2005. Sensitivity Analysis in harp seal assessment

II. Other Background Documents

Section	Title
4.4.3, 4.4.4.	DFO. 2005. Stock assessment of northwest Atlantic harp seals (Pagophilus groenlandicus). DFO Canadian Science Advisory Secretariat Science Advisory Report. 2005/037.
4.2.4, 4.3.4	Frie, A.K., V.A. Potelov, M.S.C. Kingsley and T. Haug 2003. Trends in age-at-maturity and growth parameters of female Northeast Atlantic harp seals, Pagophilus groenlandicus (Erxleben, 1777). ICES Journal of Marine Science 60: 1018-1032.
4.2.4	Haug, T., G.B. Stenson, P.J. Corkeron and K.T. Nilssen 2005.Estimation of harp seal (*Pagophilus groenlandicus*) pup production in the North Atlantic completed: Results from surveys in the Greenland Sea in 2002. ICES Journal of Marine Science 62: in press.
4.2.4, 4.3.4	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 Journal of Marine Science 52: 197-208.
4.2.4	Øien, N., and T. Øritsland 1995. Use of mark-recapture experiments to monitor seal populations subject to catching. Pp 35-45 in Blix, A.S., L. Walløe and Ø. Ulltang (eds): Whales, Seals, Fish and Man. Elsevier Science B.V., Amsterdam.
4.2.4	Salberg, A.-B., G. B. Stenson, T. Haug and K. T. Nilssen. 2005. Estimation of harp seal pup production in the Greenland Sea using spatial analysis on aerial survey data. ICES CM:2005/R:04.
4.4.3	Sjare, B., G.B. Stenson and B. Healy. 2004 Changes in the Reproductive Parameters of Female Harp Seals (*Pagophilus groenlandicus*) in the Northwest Atlantic Canadian Science Advisory Research Document. 2004/107.
4.4.4	Stenson, G. B., M. O. Hammill, J. Lawson, J. F. Gosselin and T. Haug. 2005. 2004 Pup Production of Harp Seals, Pagophilus groenlandicus, in the Northwest Atlantic. Canadian Science Advisory Secretariat. Res. Doc. 2005/037.

Annex 4: 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"), 1946–2005[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	89	5295	-	-	-	5206	89	5295
2004	4217	664	4881	-	-	-	4217	664	4881
2005	3633	119	3752[d]	-	-	-	3633	119	3752[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"), 1946–2005[a], incl. catches for scientific purposes.

	Norwegian catches			Russian catches			Total catches		
		1 year And			1 year And			1 year And	
Year	Pups	Older	Total	pups	Older	total	Pups	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	-	-	-	161	2116	2277
2004	8288	1607	9895	-	-	-	8288	1607	9895
2005	4680	1128	5808[d]	-	-	-	4680	1128	5808[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"), 1946–2005[a].

Year	Number of trips/boats	Crew number		Average duration of trips (days)	Average tonnage		Average Horse-Power
		Total	Average		Gross	Net	
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	.	.	.	.	.	.
2004	4	.	.	.	.	.	.
2005	3	.	.	.	.	.	.

[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"), 1958–2005[a,b].

Year	Number Of Vessels	Average Crew Number	Average duration of trips (days)	Average tonnage		Average Horse Power
				Gross	Net	
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	.	.	.	.	.
1995–2005[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"), 1946–2005[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	37936	0	37936	40279	2955	43234
2004	0	33	33	0	0	0	0	33	33
2005	1162	7035	8197	14258	19	14277	15420	7054	22474[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		
2003	1		
2004	0		
2005	8		

[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 1998-2005.

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 1954–2003.

	West Atlantic Population					
Year	West	KGH[b]	Southeast	Total	NE	All Greenland
1954	1097	-	201	1298	-	1298
1955	972	-	343	1315	1	1316
1956	593	-	261	854	3	857
1957	797	-	410	1207	2	1209
1958	846	-	361	1207	4	1211
1959	780	414	312	1506	8	1514
1960	965	-	327	1292	4	1296
1961	673	803	346	1822	2	1824
1962	545	988	324	1857	2	1859
1963	892	813	314	2019	2	2021
1964	2185	366	550	3101	2	3103
1965	1822	-	308	2130	2	2132
1966	1821	748	304	2873	-	2873
1967	1608	371	357	2336	1	2337
1968	1392	20	640	2052	1	2053
1969	1822	-	410	2232	1	2233
1970	1412	-	704	2116	9	2125
1971	1634	-	744	2378	-	2378
1972	2383	-	1825	4208	2	4210
1973	2654	-	673	3327	4	3331
1974	2801	-	1205	4006	13	4019
1975	3679	-	1027	4706	58[a]	4764
1976	4230	-	811	5041	22[a]	5063
1977	3751	-	2226	5977	32[a]	6009
1978	3635	-	2752	6387	17	6404
1979	3612	-	2289	5901	15	5916
1980	3779	-	2616	6395	21	6416
1981	3745	-	2424	6169	28[a]	6197
1982	4398	-	2035	6433	16[a]	6449
1983	4155	-	1321	5476	9[a]	5485
1984	3364	-	1328	4692	17	4709
1985	3188	-	3689	6877	6	6883
1986	2796[a]	-	3050[a]	5846[a]	-[a]	5846[a]
1987	2333[a]	-	2472[a]	4805[a]	3[a]	4808[a]
1988–92[c]						
1993	4983	-	1967	6950	32	6982
1994	5060	-	3048	8108	34	8142
1995	4447		2702	7149	48	7197
1996	6081	-	3801	9882	24	9906
1997	5258		2175	7433	67	7500
1998	5044		1270	6314	14	6328
1999	1488	-	1682	3170	4	3174
2000	3773	-	2046	5819	29	5848
2001	4820	-	1439	6259	5	6264
2002	2644	-	881	3525	10	3535
2003	4334	-	1973	6307	10	6317

[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 1993–2003 (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
2002	49,530	44	1,535	20	59	93	51,124
2003	64,683	44	2,805	24	34	100	67,522

[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"), 1946–2005[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
2004	0	0	0	0	353553	12418	0	365971	353553	12418	0	365971
2005[f]	0	0	0	0	319127	4699	0	323820	319127	4699	0	323820

[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

[f] Preliminary estimates

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

	Bowen[1]			D.E.S.[2]	Roff & Bowen[3]				Stewart et al.[5]			NWMB[6]
Year	0	1+	Total		0	1+	Total	NAFO[4]	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	
1997												1804
1998												719
1999												368
2000												280
2001												405

[1] **Bowen, W. D. 1982. Age structure of Northwest Atlantic harp seal catches, 1952-84050. *NAFO Sci. oun. Studies*, 3: 53-65. Mean catch of 1768 for years 1962-1971 from Smith and Taylor (1977) and alues 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 arp seal (*Phoca groenlandica*) from 1967 to 1985. *Can. J. Fish. Aquat. Sci*., 43: 553-564.**

[4] **Anonymous. 1985. Provisional report of the Scientific Council. NAFO SCS Doc. 85/I/2. Values nclude 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 anada's northern and Arctic regions. *Fish. Aquat. Sci. Tech. Rep.*, No. 1463.**

[6] **Anonymous. 2005. The Nunavut Wildlife Harvest Study. Nunavut Wildlife Management Board. qaluit, Nunavut, Canada.**

Table 12.Hooded seal catches off Newfoundland and in the Gulf of St. Lawrence, Canada ("Gulf" and "Front"), 1946–2005[a,b]. Catches from 1995 onward include catches under the personal use licences.

	Large Vessel Catches				Landsmaen Catches[c]				Total Catches			
Year	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[e]	0	0	0	0	0	201	0	201	0	0	201	201
2000[e]	2	2	0	4[d]	0	10	0	10	2	2	10	14
2001[e]	0	0	0	0	0	140	0	140	0	0	140	140
2002[e]	0	0	0	0	0	150	0	150	0	0	150	150
2003[e]	0	0	0	0	0	151	0	151	0	0	151	151
2004[e]	0	0	0	0	0	389	0	389	0	389	0	389
2005[ef]	0	0	0	0	0	20	0	20	0	20	0	20

[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; commercial catches of bluebacks are not allowed

[f] Preliminary estimates

Annex 5: SUMMARIES OF SEALING REGULATIONS

Table 1. Summaries of Norwegian sealing regulations for the Greenland Sea ("West Ice"), 1985–2005.

	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	
2004-05	22 March	10 July	5,600[12]				5,600	
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]
2001-05	10 April	31 May	15,000[13]				15,000	

[1] **Other regulations include: Prescriptions for date for departure Norwegian port; only one trip er 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 easons.**

[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 ups 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 qualled one 1+ animal.**

Table 2. Summary of sealing regulations for the White and Barents Seas ("East Ice"), 1979–2005.[1]

Season	Opening dates		Closing date	Quotas – Allocations		
	Soviet/ Russian	Norwegian sealers		Total	Soviet/ Russia	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
2004-05	-	-	-	45,100[6]	35,100	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, 1960–2005.

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 (1960–2005).

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.

Annex 6: Review of the ICES/NAFO Working Group on Harp and Hooded Seals (WGHARP)

Review by Correspondence

Review group: Michael C.S. Kingsley, Poul Degnbol

WG Chair: Tore Haug

General remarks

The terms of reference for the meeting were that WGHARP should:

1. Further the development of biological reference points for harp and hooded seals;
2. Review the results of intersessional modelling studies to look at sensitivity analyses and comparisons between models;
3. Review the results of proposed pup production surveys in the NW Atlantic;
4. Assess the impacts on the stocks of harp and hooded seals in the Greenland Sea and of harp seals in the White and Barents seas of certain harvest levels;
5. Review the recent assessment of the status of harp seals conducted by Canada. (WGHARP is to report this review to (scil. ICES) Scientific Council on 19–23 Sept, i.e. before the present review is completed.)

One general comment would be that more attention to units would be appreciated. It is implied in various equations &c, that mortalities given are instantaneous, in which case the dimensions are $[T^{-1}]$, and in the present document the units are presumably per year, although this is never stated. This becomes relevant at the top of p.12 where there is mention of 'values of natural mortality . . . 0.7, 0.8, 0.9'—these are presumably discrete-time annual survival values, as they can hardly be instantaneous mortalities per year, but this also is not stated.

1. Material related to TOR 1 is found on pp. 19–22 of the meeting report.

The development of biological reference points for seals is complicated by a certain level of ambiguity as to their objective, which is not addressed; the reference points developed seem to be those appropriate to a valued resource for which the objective is a sustained high biomass and a high level of sustainable exploitation. 70% of the maximum recorded population size is presented as a *precautionary* level, which populations should be maintained above, without much justification.

The WG has enunciated definitions for 'data-rich' and 'data-poor' stocks; a questionable point is the requirement for 'data-rich' stocks that abundance estimates should be unbiased—something which is in principle difficult to know. It would be helpful if the material at the bottom of p. 22 were to come at the start of Sec. 6.2, since it conditions the material at the top of p. 21, for example. The difference between 2. a) and 1. h) in this section is hard to see.

The WG takes ACFM slightly to task for referring to N_{70} as a 'Target Reference Point', but seems to be using that term in Fig. 3. The significance of the BRPs set here seems to be that a target could never be set lower than 70% of the hitherto highest stock abundance estimate.

Reference is made to a 'PBR protocol' without much specification of what it involves; in fact PBR includes a couple of more or less subjectively chosen values for parameters.

The oblique dark line in Fig. 3 is what, exactly? (Apart from being an oblique dark line with a few kinks in it.)

There is however some serious problems with the response to the TOR: there are no conclusions regarding proposals for reference points for the specific stocks and it is not at all clear how such conclusions could be drawn at this time as all the stocks for which models are available are at their historical highest and it seems that reference points based on population numbers and Nmax basically cannot be implemented in such a situation. The WG states that the subgroup will continue its work on establishing reference points for the specific stocks but it is not clear how that can actually be done and if it can be done what has prevented the group

from doing it here and now. Alternative frameworks based on exploitation rates rather than stock sizes might be more usefull in the present situation but such frameworks seem not to have been investigated.

TOR 2. Material on the review of the intersessional modelling work is found on pp. 3–6, with some further material in Sec. 4.2.4. on pp. 7–10.

There are some small confusions, for instance the proportion mature is described as the proportion 'reproductively active', which is supposed to be distinguished from F, the proportion 'giving birth'; quite what is the difference between reproductive activity and giving birth is not clear. More significantly, p is described as time-variant while F is given as constant, but this doesn't seem to fit with the schedule of Table 1, and would in any case be an unusual hypothesis from a biological point of view. Wouldn't ircumstances that delay maturity tend also to reduce pregnancy rates in the mature? (Incidentally, if p is varying with time, doesn't there have to be a constraint that $p_{i+1,t+1}$ is at least as large as $p_{i,t}$?)

It's not quite clear why the posterior estimates of Table 3 differ from those of Fig. 1. The WG chair has informed the review group that it is the values in Figure 1 which are correct. *Prima facie* there seems to be a possible problem with the trajectory of pup numbers modelled in Fig. 1, in that it closely follows the low survey estimates of the 1980s and ignores the high ones. This is presumably because the high estimates have large uncertainty—but high estimates nearly always do. The impression given is that the uncertainty about these survey estimates is being taken as symmetrical, which in truth it probably isn't, and unsymmetrical uncertainty curves might alter this result. This comment is significant in the context of the assessment of the impact of takes (see TOR 4).

All in all, effortsw to model these stocks appear to be bedevilled by lack of data, especially on numbers of adults. It appears that the models are constrained to estimate numbers of adults from estimates of numbers of pups by using concomitant estimates of population mean birth-rate (which there isn't much information on in this document). Attempts to model age-specific mortality of non-pups would appear to depend on having *really* good data on the age structure of the population. It may be noted that Siler-type models can be used to summarise age-specific mortality in a few parameters, but even so it might be expected that these few values will tend to be highly correlated in the model fits. Multiplying the number of parameters that are estimated will not increase the amount of information available, and the dispersion of the parameter estimates will always be constrained by the available information, so it can almost be expected that correlations will proliferate.

A quick modelling exercise, building the equations of p. 8 into an Excel spreadsheet and using naive likelihoods for the fits to the survey data and also to the prior estimates for the parameters produced estimates of pup numbers in 2005 of 108 000 (s.e. 18 000 from a likelihood support interval) and of adults 609 000 (103 000); estimates of life history parameters were 0.274/yr (0.04), 0.091/yr (0,013), and 0.644 (0.08). The model does seem to be doing some genuine updating of the estimates of the life-history parameters.

TOR 3. Review the results of proposed pup production surveys in the NW Atlantic.

Relevant material for harp seal surveys in the NW Atlantic is found on p. 16 of the report**;** it is difficult to discern the results of the Working Group's review of the survey as the WG report includes no comments on it: The presentation is too brief to allow much further review but reference is made to a separate publication which will not be reviewed here.

The statement 'comparison with previous estimates indicates that pup production has not changed' should probably read '. . .does *not* indicate that production *has* changed'. Results from whelping-patch surveys of hooded seals carried out in the NW Atlantic in 2005 are not yet available.

The methods used in, and a brief narrative of field activities under, an aerial survey of hooded seals in the Greenland Sea, are given on pp. 17–18; again, the description is too brief to permit much review but reference is made to a separate publication.

TOR 4. Assess the impact that certain harvest levels would have on stocks of harps and hoods in the Greenland Sea and on harps in the White Sea.

Specifically, the request is to assess the impact on these stocks of annual harvests at current levels, levels that stabilise the 1+ population (presumably at its present size), and at twice this sustainable level. This assessment has been carried out for harps in the Greenland Sea from predictive runs of a model of the population dynamics, with results that current harvest will permit continued increase in the stock, sustainable harvests will keep the stock at its current level, and takes at twice sustainable level will cause it to decrease.

This assessment is basically a reflection of the recent trajectory. The surveys show an increasing pup production, so the values of life-history variables obtained by population dynamics modelling will be such that when put back into a predictive model run, they will show that current takes will allow the population to increase—i.e. the asssessment of the future effect of current takes is almost certain to be the same as their effect in the recent past. The current assessment that these takes are allowing the stock to increase is largely derived from the model that fits the pup production trajectory to the low pup-number estimates of the 1980s rather than to the high ones. Similarly, sustainable takes will be higher than current ones, and takes at double the sustainable level will reduce numbers.

TOR 5. Review the recent assessment of the status of harp seals conducted by Canada.

Material related to the assessment is very briefly given on pp. 16–17. It is difficult to know what, if anything, WGHARP did in the way of reviewing this assessment, as the Working Group's report includes no comments on it.