Northwest Atlantic Fisheries Organization

Serial No. N4460 **NAFO SCS Doc 01/23**

SCIENTIFIC COUNCIL MEETING – JUNE 2001

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

ICES Headquarters, Denmark
2–6 October 2000

by

ICES/NAFO Working Group

Advisory Committee on Fisheries Management **ICES CM 2001/ACFM:08**

REPORT OF THE

JOINT ICES/NAFO WORKING GROUP ON HARP AND HOODED SEALS

ICES Headquarters
2–6 October 2000

International Council for the Exploration of the Sea

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 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, the Joint Working Group met for the first time in October 1991 (ICES CM 1992/Assess:5).

The Joint Working Group 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 Archangelsk, Russia (ICES CM 1993/N:2).

The Joint Working Group 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, the Joint Working Group 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.

Based on a request from the Joint Norwegian-Russian Commission, and on some outstanding questions from the 1998 meeting, ACFM formulated the following terms of references for the Joint ICES/NAFO Working Group on Harp and Hooded Seals [WGHARP] (Chair: Prof. T. Haug, Norway) to deal with when it met at ICES Headquarters in Copenhagen, Denmark from 2 to 6 October 2000:

a) complete the assessment of stock size and pup production of harp seals in the White Sea / Barents Sea and of hooded seals in the Greenland Sea;
b) assess the sustainable yield at present stock sizes for the above two stocks and provide short- and medium-term catch projections for these stocks as well as for Greenland Sea harp seals;
c) identify B_{lim}, B_{msy} and other relevant biological reference points for Greenland Sea harp seal, Greenland Sea hooded seal, and the White Sea / Barents Sea harp seals;
d) examine current biological reference points used for harp and hooded seals, and consider the appropriateness of these and other possible reference points (including B_{lim} and B_{msy}) for the stocks of Greenland Sea harp and hooded seals and White Sea / Barents Sea harp seals;
e) summarise new information on predation on commercially important fish stocks by marine mammals;

f) agree on objectives and presented plans for the forthcoming Workshop on Population Modelling of Pinnipeds.

Items c) and d) were formulated to provide ACFM with the information required to respond to the requests for advice/information from the Joint Norwegian-Russian Commission. WGHARP will report at the 2001 Annual Science Conference and to ACFM at its October/November 2000 meeting. Furthermore WGHARP will report to the NAFO Scientific Council at its meeting in May 2001.

2 MEETING ARRANGEMENTS

The Working Group, chaired by T. Haug, and comprised of scientists from Canada, Denmark, Greenland, Norway, Russia, and USA met at the ICES Headquarters in Copenhagen, Denmark, 2 to 6 October 2000. A list of participants is given in Appendix I.

The Working Group reviewed available information on catches and relevant scientific information on harp and hooded seals and on precautionary approach and biological reference point issues, 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. Gosselin, Merrick, Nilssen, Øien and Stenson agreed to assist the Chair as rapporteurs.

3 HARP SEALS (*PHOCA GROENLANDICA*)

3.1 Stock Identity, Distribution and Migration

Analysis of mitochondrial DNA from a small sample of animals collected in each of the four individual whelping areas (White Sea, Greenland Sea, Front and Gulf) confirm that the Northeast and Northwest Atlantic populations should be maintained as two different stocks (Perry *et al*., 2000). Samples from the White Sea and Greenland Sea could not be distinguished, but given the small sample size, it is unlikely that small differences would be identified. Although a 6 year old animal tagged in the Greenland Sea was recovered just outside the White Sea during the moulting period (Øien, this meeting SEA-112), there are no reports of the exchange of mature adults between these two whelping areas (Øien and Øritsland 1995) which suggests that there is reproductive separation. Therefore, these two stocks should be managed separately unless further studies indicate otherwise.

Perry *et al*. (2000) were also unable to separate samples from the Front and Gulf whelping concentrations. However, large variations in the proportion of pups born in the different areas (Stenson *et al.*, 2000a) over the years suggests that animals move among whelping locations in the NW Atlantic.

Analysis of a larger sample from the different whelping areas is necessary to determine stock relationships. Cooperative work between Norway, Iceland and Canada using DNA sequence analysis and microsatellite analysis has been initiated to assess stock identity.

3.2 The Greenland Sea Stock

3.2.1 Information on recent catches and regulatory measures

Available information on Norwegian catches of harp seals in the Greenland Sea pack-ice in 1999 and 2000 are listed in Appendix IV, Table 2. Russia has not participated since 1994. The total catches were 803 (including 608 pups) and 11,555 (5610 pups) animals in 1999 and 2000, respectively. The figures for 2000 are preliminary. Removals were well below allocated quotas which in both years were 17,500 animals one year old or older (1+ animals). Parts of, or the whole quota, could be taken as weaned pups assuming 2 pups equaled one 1+ animal.
Available information on Norwegian and Russian sealing effort directed towards harp and hooded seals in the West Ice is given in Appendix IV, Tables 3 and 4.

3.2.2 Current research

Norwegian scientists have collected data on the condition of pups in the whelping areas during 1999 and 2000; data on the age composition of adults harvested was collected in 2000. Reproductive data collected by Russia and

Norway from the early 1960's to recent years has been reanalysed (Hatlestad 1999, Frie *et al*., this meeting SEA-101).

Live seals were captured at the whelping grounds and physiological studies are being conducted in Norway. Satellite tags have been deployed on newly moulted harp seals captured in the Greenland Sea in 1999. These data are being analysed and will be submitted for publication.

In Norway, a project is now underway to estimate the ecological importance of harp seals and hooded seals in the Greenland Sea. Samples are being collected throughout the year (summer, fall and winter) to estimate body condition and diet composition using stomach contents and fatty acid analysis.

There has been no active research by Russia in the Greenland Sea since 1994.

3.2.3 Biological parameters

Mean age of sexual maturity (MAM), fertility rates and length were estimated from samples collected by Russian scientists in the Greenland Sea between 1959 and 1991 (Frie *et al*., this meeting SEA-101). Based on the most recent year, ovulation rates were constantly high throughout the early 1960's to 1991 period. MAM varied from 5.1 years in 1959-64 to 6.9 years in 1991. However, no trend was present. Postpartum pregnancy rates (based on samples obtained during the moulting period) were variable (77.9 – 92.3%) through the years, although there is some uncertainty in the constancy in the identification of structure during laboratory analysis from old to recent samples. Growth rates in Greenland Sea harp seals showed no variations throughout years from the early 1960s to 1991.

Analysis of pregnancy rates obtained from Norwegian samples collected in the Greenland Sea has been carried out using the back-calculation technique (Hatlestad 1999). However, the results were not available to the Working Group. Frie *et al*. (this meeting, SEA-101) found that the back-calculated estimates of MAM were strongly correlated to the age distribution of the sample. The Working Group suggested that these two data sets be combined and a common method be used to estimate reproductive parameters.

3.2.4 Population assessment

During the year 2000, a total of 48 1+ seals tagged in the West Ice as pups were recaptured by Norwegian sealers. From the most recent tagging effort on the 1991 cohort alone there were 15 recaptures. Since the age distribution of the year 2000 catches is not yet available, it was not feasible to update the earlier pup production estimates by including the new recapture information. The last update of mark-recapture estimates for harp seals in the Greenland Sea was presented at the last meeting of the Working Group (ICES CM Doc 1999/ACFM:7) and included data up to and including 1995. Since then catches of 1+ seals in the West Ice have been low and, until this year, few tags have been returned. The most recent estimate of the Greenland Sea harp seal pup production in 1991 is 67,300 (95% C.I. 56,400-78,100; ICES CM 1999/ACFM:7).

At the previous meeting of the Working Group population assessments were presented based on a population dynamics model originally described by Ulltang (ICES CM 1990/Assess:8). Skaug and Øien (this meeting, WP SEA-102) presented a new population model that estimates the development of future population size, for which statistical uncertainty is provided for each set of catch options. The age structure of the model was reduced to two age classes (0 and 1+) because of limited information on catch-at-age and age structure for Greenland Sea and White Sea harp seals, and for Greenland Sea hooded seals. The model requires estimates of mortality and reproductive parameters that include variance. Using the historical catch data and estimates of pup production, the model estimates mortality (M) and a birth rate within the 1+ population of females (f). The proportion of females in the population giving birth each year is:

$$f = F \cdot \frac{\sum_i p_i \exp(-i \cdot M)}{\sum_i \exp(-i \cdot M)}.$$

where

F = the pregnancy rate of mature females;
p_i = the proportion of females age i that are mature.

The freedom with which the model can estimate these parameters is dependent upon the standard deviations provided. The model is fitted to pup production estimates weighted inversely to their variance.
To investigate how the new model compares to the older one, a run of the new model with the same parameters as one of the 1998 runs was conducted. An exact replicate could not be run, but results were close enough to confirm that these two models were consistent.

The Working Group noted that the possibility of including multiple pup production estimates is an improvement from previously used estimation programs. However, models of this nature do not estimate parameters well when there are limited estimates of pup production available. In the 1998 assessment, biological parameters were fixed, and not estimated during the runs. Therefore, the uncertainty associated with the estimates of population size and sustainable catch cannot be estimated. The present model has the option to allow estimation of these parameters, but when it is given no prior information about M_{1+} and f, the model treats these parameters as independent parameters. During the meeting it was realised that this is inappropriate, and therefore, prior information to restrain the variance on the parameters had to be provided. As a result, the estimates of uncertainty are negatively biased. Finally, concerns were raised about the effect of large annual variations in pup catch levels on an age-aggregated model. It was therefore **recommended** that simulation studies should be carried out to determine the sensitivity of the model to variations in the age structure of the catch.

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

Natural mortality: $M_{1+} = 0.11$, sd. = 0.03.

The M_{1+} value is similar to what has been used in recent assessments of the stock while the standard deviation is based on analyses conducted for Northwest Atlantic harp seals (Healey & Stenson 2000). A standard deviation of .03 means that one effectively considers values of M_{1+} in the range from 0.05 to 0.17.

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

Age at maturity ogive: p(3) = 0.058, p(4) = 0.292, p(5) = 0.554, p(6) = 0.744, p(7) = 0.861, p(8) = 0.926, p(9) = 0.961, p(10) = 0.980, p(11) = 0.990, p(12) = 0.995, p(13) = 0.997, p(14) = 0.999, p(15) = 0.999 (fixed; Frie *et al*., this meeting, SEA-101).

Pregnancy rate for mature females: f = 0.833, sd. = 0.02.

This is estimated from Frie *et al*. (this meeting, SEA-101). Based on pregnancy rate and age-at-maturity ogive a birth rate for the 1+ population (f) is calculated and used in the model.

Pup production estimates:

Table 1 Estimates of Greenland Sea harp seal pup production. From Øien and Øritsland (1995).

Year	Estimate	c.v.
1983	58539	.104
1984	103250	.147
1985	111084	.199
1987	49970	.076
1988	58697	.184
1989	110614	.077
1990	55625	.077
1991	67271	.082

Table 2 Estimated 2000 abundance of harp seals in the Greenland Sea.

Parameter	Estimate	95% C.I.
1+ population in 2000	361,000	210,000 – 629,000
Pup production in 2000	76,700	48,000 – 105,000
M_{1+}	0.12	0.09 – 0.15
M_0/M_{1+}	3.10	1.26 – 4.95
f (birth rate for 1+ females)	0.50	0.38 – 0.61

The estimate of the 1+ population in 2000 is close to that provided at the last meeting (ICES CM Doc 1999/ACFM:7). However, the mortality estimate is greater than that assumed previously.

3.2.5 Catch options

Options are given for two different catch scenarios: current catch level (average of the catches in the period 1996 – 2000) and sustainable yield. The sustainable catches are defined as the (fixed) annual catches that stabilises the future 1+ population. The catch options are further expanded using different proportions of pups and 1+ animals in the catches.

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

$$D_{1+} = \frac{N_{2010,1+}}{N_{2000,1+}}.$$

Table 3. Catch options with corresponding population trend (D_{1+}) for the next 10-year period for harp seals in the Greenland Sea.

Opt. #	Catch level	Proportion of 1+ in catches	Pup catch	1+ catch	D_{1+}	Lower 95% C.I for D_{1+}	Upper 95% C.I for D_{1+}.
1	Current	14% (1996-1999 level)	3600	600	1.31	0.88	1.75
2	Current	51% (2000 level)	2000	2200	1.30	0.86	1.74
3	Current	100%	0	4200	1.28	0.84	1.72
4	Sustainable	14%	17600	2900	1.00	0.52	1.49
5	Sustainable	51%	8500	9000	1.01	0.51	1.50
6	Sustainable	100%	0	15000	1.00	0.50	1.50

Under the current catch level (Options 1-3) the table indicates an increase in population size ($D_{1+}>1$), but the confidence interval for D_{1+} also includes values of D_{1+} less than one, i.e. the possibility of a decrease in the population size under the current catch level cannot be ruled out. Under the sustainable catches (Options 4-6) the confidence bounds indicate that if this catch level is maintained for a 10-year period, the population size could change by 50%.

3.3 The White Sea and Barents Sea Stocks

3.3.1 Information on recent catches and regulatory measures

Recent Russian and Norwegian catches of harp seals in the White and Barents Sea are listed in Appendix IV, Table 5. In 1999, the combined catches were 36,000 animals, of which 35,023 were pups. This is below the sustainable yields recommended by the Working Group in 1998 – 21,400 1+ seals or 53,500 pups (where 2.5 pups equalled one 1+ animal). In 2000, preliminary estimates of the combined catches were 44,770, of which 40,556 were pups. Again the total catch was within the sustainable yield provided by the Working Group for 2000 – 22,700 1+ seals (or 56,750 pups) (Appendix V, Table 2).

In addition, incidental catches of 488 and 439 harp seals were recorded in Norwegian gill net fisheries in 1999 and 2000, respectively (Appendix IV, Table 6).

3.3.2 Current research

Russian data on morphometric analyses of harp seals taken during whelping and moulting seasons in the White Sea in 1994-1999 were presented (Svetochev *et al.*, this meeting, SEA-103). Norwegian researchers collected data on body condition of pups and on age composition of 1+ seals during the commercial sealing on the moulting grounds in the Barents Sea in 2000. A few samples were collected for diet studies from seals caught incidentally by coastal gill net fisheries in northern Norway during late winter in 1999 and 2000.

Preliminary results of 1998 aerial surveys of harp seal pup production were presented at the last Working Group meeting (ICES CM 1999 / ACFM:7). Reanalysis of these surveys was presented at this meeting (Chernook *et al*., this meeting, SEA-109). Aerial surveys using helicopter (10-12 March) and fixed-wing aircraft (18 March) were conducted by Russian researchers to estimate the harp seal pup production in the White Sea in 2000 (Potelov *et al*., this meeting, SEA-110; Chernook *et al*., this meeting, SEA-106).
No tagging was carried out in 1999-2000. Data from Russian taggings in 1995-1997 are lacking in the Norwegian data base. These data are required in order to estimate pup production.

3.3.3 Biological parameters

Analysis of body condition data from harp seal pups collected on whelping grounds in the White Sea in 1999 showed that an observed decrease in body mass during the moulting period was due to a decrease in core mass, while sculp mass remained constant (Svetochev, this meeting, SEA-103). The Working Group discussed potential studies on variation of fat content in different seal tissues to determine which tissues are contributing the most to the observed decrease in core mass. Body condition of adult females collected on the whelping grounds during the period 1994-1999 was significantly higher compared with females taken during moult. No significant difference in body condition was found between adult females and males on the moulting grounds (Svetochev, this meeting, SEA-103). The Working Group noted that pup and adult analyses should be separated by stage and age, respectively.

3.3.4 Population assessment

Pup production in 1998

Preliminary results of aerial surveys of the White Sea conducted on 7, 8, and 16 March 1998 were presented to the Working Group at the 1998 meeting (ICES CM 1999 / ACFM:7). Chernook *et al*. (this meeting, SEA-109) reanalyzed results obtained from these surveys and completed analysis of a survey carried out on 12 March 1998, taking into account potential methodological biases (Shavykin *et al.*, this meeting, SEA-104). The revised uncorrected estimates of pup production were slightly lower than those presented at the last meeting.

Counts of harp seal pups obtained from aerial survey photos require corrections for pups not born at the time of the survey and for pups not seen or mis-identified by the readers. The Working Group was concerned that the model used to estimate the proportion of pups present on the ice was unclear. Stage duration data collected during the survey period indicated that the 7 March survey required a significant correction for births that occurred after the survey period, while the suggested 12 and 16 March surveys required little or no correction.

Chernook *et al*. (this meeting, SEA-109) developed correction factors for unseen pups through a comparison of counts made by teams on the ground with the aerial survey count obtained for the same place and time. The Working Group was concerned that the number of such counts available was too low to be used for corrections. A larger number of sites should be selected which would include a range of surveys conditions (especially time of day and visibility). In addition, an estimate of the uncertainty associated with the correction factor used for each survey must be determined and incorporated into the total variance of the survey.

An alternative method was presented for calculating pup production using adult counts from visual imagery and pup/adult rations obtained from the ultra-violet images (Chernook *et al.*, this meeting, SEA-109, Shavykin *et al.*, this meeting, SEA-104). For each survey, a pup/adult count was calculated and applied to the total number of adults observed. The resulting pup estimates were consistent with those obtained by directly reading the black and white and the infrared images. However, the Working Group noted that use of a single ratio, as in this analysis, was

inappropriate for correcting an entire survey. As much as possible, ratios should be estimated on photo or transect basis. This would reduce any potential biases due to changes in the proportion of adults on the ice throughout the day. This would not account for potential biases associated with diurnal variations in the ability of readers to identify pups when estimating pup/adult ratios, but this issue may be addressed by examining data from a series of control sites that were photographed at different times of the day. The estimation of all ratios should include an estimate of the variance associated with the pup/adult ratio and this variance should be incorporated in the total variance of the survey.

In summary, the Working Group **recommends** that the uncorrected pup counts be used. Using a conservative approach, the Working Group concluded that an average of the uncorrected estimates from the 12 and 16 March surveys would provide a minimum estimate of pup production. The mean of these two surveys, weighted by the inverse of the variance, resulted in an estimated 1998 pup production of 286,260 (SE=20,844).

Pup production in 2000

An aerial photographic (black and white) survey of the whelping grounds in the White Sea was conducted on 10-12 March 2000 (Potelov *et al.,* this meeting, SEA-110). Using the strip transect method the mean uncorrected estimate of pups was 322,474 (SE=28,706) including pups harvested prior to the survey (30,729 pups). This estimate was accepted by the Working Group. A somewhat higher estimate was obtained when the data were analysed using the isoline method (Potelov *et al*. 1997, 1998, SEA-93), which gave a mean uncorrected estimate of pups (including catch) of 346,200 (SE=8,653). None of the estimates were corrected for pups born after the survey. The Working Group noted that the isoline method, based on kriging in this example, is highly sensitive to the options used. The group **recommended** that their Russian colleagues further investigate the isoline method, and that the options used for the estimate be clearly described when the results are presented.

Preliminary results of an aerial survey of the White Sea harp seals conducted by Russian scientists on 18 March 2000 were presented (Chernook *et al*., this meeting, SEA-106). Like similar surveys conducted in 1997-98 (Chernook *et al*. 1997a,b; Shaficov and Chernook 1997; Chernook *et al*., 1998, SEA-92; Chernook *et al*., this meeting SEA-109), the survey was conducted by traditional strip transect methods using multiple sensors. As in the previous surveys these included black and white photography, but thermal infrared (IR) scanning and video cameras (25º and 6º vision angles) replaced IR-photo cameras. All devices were operated simultaneously during the survey. However, only preliminary results from a combination of video (25º) and IR, which covered a strip width of 78.2 meters, and IR-camera, which covered 224.8 meters, were presented. The IR and video (6º) were compared to correct for pups not visible to the video (25º) camera. The pup abundance and SE were estimated for each transect line, but an average correction factor (1.08 ± 0.05) for the entire whelping ground was used to correct the original estimate of pup numbers. The Working Group was concerned that it was unclear how the correction factor was determined, and more importantly, again felt it was inappropriate to use a single correction factor for an entire survey. Therefore, the Working Group **recommends** the use of the uncorrected pup production estimate of 339,710 (SE=32,400) which includes pups harvested prior to the survey (30,729 pups).

The Working Group **commended** the Russian scientists for the high quality of the research in both the fixed-wing and helicopter surveys and encouraged them to continue the analyses and to publish the final results. The estimates from both year 2000 surveys confirm the 1998 estimate accepted by the Working Group (ICES CM 1999 / ACFM:7), and give strong evidence of a harp seal pup production of at least 300,000.

Population modelling

Using the model described by Skaug and Øien, (this meeting, SEA-102) for the White Sea / Barents Sea harp seals, the following parameters were used:

Natural mortality: $M_{1+} = 0.1$, sd. = 0.015.

The M-value is similar to what has been used in recent assessments of the stock while the standard deviation is based on the assumption that M should be bounded by the assumed interval [0.07, 0.13] (NAFO SCS Doc. 83/VI/21).

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

Age-at-maturity ogive: p(5) = 0.1, p(6) = 0.18, p(7) = 0.35, p(8) = 0.6, p(9) = 0.7, p(10) = 0.94, p(11) = 1.0 (fixed; Kjellqwist *et al*., 1995).

Pregnancy rate: f = 0.84, no standard deviation (Kjellqwist *et al*., 1995).

Pup production estimates

Table 4 Estimates of Barents Sea / White Sea harp seal pup production.

Year	Point estimate	c.v.
1998	286,260	.073
2000	322,474	.089
2000	339,710	.095

The Working Group noted that these estimates of pup production are uncorrected and that the degree of correction that should be applied to each survey may not be the same. Therefore the model was fit to data under two different assumptions about the ratio M_0/M_{1+}:

Table 5 Estimated 2000 abundance of harp seals in the White Sea/Barents Sea.

Parameter	Estimate	95% CI
$M_0/M_{1+} = 3.0$		
1+ population in 2000	1,727,000	1,550,000 – 1,910,000
Pup production	319,000	286,000 – 351,000
M_{1+}	0.10	0.07 – 0.12
M_0/M_{1+}	3.0	Fixed
f (birth rate for 1+ females)	0.42	Fixed
$M_0/M_{1+} = 5.0$		
1+ population in 2000	1,676,300	1,500,000 – 1,850,000
Pup production	314,000	283,000 – 346,000
M_{1+}	0.09	0.07 – 0.11
M_0/M_{1+}	5.0	Fixed
f (birth rate for 1+ females)	0.42	Fixed

The estimated 1+ population for year 2000 is approximately the same as that found in the 1998 assessment. Because the ratio M_0/M_{1+} and the birth rate (f) has been fixed (and hence the uncertainty about these parameters has been ignored), the uncertainty about the other parameters will be underestimated.

3.3.5 Catch options

Catch options are given for current catch levels and sustainable yields.

Table 6. Catch options with corresponding population trend (D_{1+}) for the next 10-year period for harp seals in the White Sea / Barents Sea.

Option #	M_0 / M_{1+}	Catch level	Proportion of 1+ in catches	Pup catch	1+ catch	D_{1+}	Lower 95% C.I. for D_{1+}	Upper 95% C.I. for D_{1+}
1	5	Current	12.5% (current level)	35000	5000	1.16	0.80	1.52
2	5	Current	100%	0	40000	1.09	0.73	1.45
3	3	Sustainable	12.5%	95000	14000	1.02	0.62	1.42
4	3	Sustainable	100%	0	82000	1.02	0.61	1.45
5	5	Sustainable	12.5%	69100	9900	1.02	0.68	1.35
6	5	Sustainable	100%	0	53000	1.01	0.66	1.37

The sustainable catches are higher than those calculated during the 1998 assessment (ICES CM Doc 1999/ACFM:3). The reason for this is that the estimated mortality in the current assessment is lower ($M_{1+} = 0.09$) than that assumed previously ($M_{1+} = 0.1$). Estimating mortality is difficult in the current model because the available pup production estimates are located closely in time. Therefore a cautious approach is recommended.

3.4 The Northwest Atlantic Stock

3.4.1 Information on recent catches and regulatory measures

The increased catches observed in southern Canada (>240,000) continued until 1999 (Appendix IV, Table 10). However, preliminary estimates indicate that catches at the Front and in the Gulf declined to a little over 90,000 in 2000. This decrease appeared to be due to poor market and weather conditions. Catch has consisted primarily (>85%) of seals less than 1 year of age.

Recently, the Nunavut Wildlife Board conducted a harvest survey that should provide information on recent catches in the Canadian Arctic. The results of this survey have been requested.

Since 1980, Greenland catches have continued to increase to over 89,000 in 1998 (Appendix IV, Table 9a). In 1999, catch data was only available until September. However, based on catches during the first nine months and the proportion of catches that occur during this period in recent years, an estimate of approximately 100,000 harp seals was obtained (Stenson *et al*., 2000b).

An analysis of historical data on the age composition of catches of harp seal in Greenland was presented (Kapel, this meeting, WP SEA -111). The data which have been used for the construction of catch-at-age series demonstrate changes in age composition during the period 1970-83, and indicate a continuation of similar developments during the following years (Stenson *et al*., 2000b). The change includes a decreasing dominance of young of the year in the Northwest and Central West Greenland, and a simultaneous increase of immature harp seals of the age group 1-4. The data does not allow firm conclusions on the present age composition of harp seal catches in Greenland, or whether the data for Northwest and Central Greenland are applicable for all Greenland.

In addition to reported catches, some seals are killed but not recovered (referred to as 'struck and lost'). Studies have been carried out to estimate struck and lost rates in the Canadian harvest (Anon. 2000). Loss rates for young of the year seals appear to be low (less than 5%) while losses of older seals is higher. Loss rates for seals shot in the water are more variable but generally higher than those taken on the ice. For modelling purposes, loss rates for young of the year in southern Canada are assumed to be 5% while 50% of older (1+) seals are assumed to be lost. This higher figure is also applied to catches in the Canadian Arctic and Greenland, but studies are required to verify if these are appropriate.

The number of harp seals taken as by-catch in the Newfoundland Lumpfish fishery has also been estimated (Anon 2000). Fewer than 10,000 animals were taken annually from the start of the fishery in 1968 until 1984. Since 1984, by-catches have been more variable, ranging between 3,000 and 36,000 per year. Recent by-catches (1996-1998) have

varied between 16,000 and 23,000 seals annually. Additional seals are taken in other fisheries but the numbers caught have not been estimated. A small number of harp seals (~380/yr) are taken in fishing gear in the northeastern U.S. (Waring *et al*., 1999).

Total annual removals (including reported catches, struck and lost, and by-catch) in Northwest Atlantic were in the order of 465,000 between 1996 and 1999. In 2000, Northwest Atlantic removal appear to be lower due to the reduction in Canadian catches. However, current catches in Greenland are unknown.

3.4.2 Current research

An assessment of the Northwest Atlantic harp seal population was carried out by Canadian scientists and externally peer reviewed (Anon. 2000). The assessment incorporated estimates of pup production obtained in 1999, and recent data on Canadian and Greenland catches, reproduction rates, estimates of struck and loss during hunt, and by-catch in the Newfoundland lumpfish fishery. Additional Canadian studies include analysis of growth rate in foetal harp seals (Chabot and Stenson 2000), determination of contaminant levels (Zitko *et al*., 1998, Yeats *et al*., 1999), diet composition and consumption estimates (Hammill and Stenson 2000).

In Greenland, collections to address morphometric, condition, diet composition and age composition of the catch are continuing. In addition, analysis of historical data on growth is being pursued. Cooperative studies between Greenland and Canada are being conducted to assess pregnancy rates, ovulation rates and MAM for this stock.

The current population model estimates are based upon stepwise pregnancy rates (Healey and Stenson 2000). The use of smoothed pregnancy rates is being investigated and will be included in future runs of the model.

3.4.3 Biological parameters

Reproductive parameters of NW Atlantic harp seals have varied considerably since the 1950s (Anon. 2000). The percentage of mature females that were pregnant increased from the mid-1950s (85%) to the mid-1960s (95%). However, it has dropped significantly from approximately 90% in the early 1980s to only 70% during the early 1990s. It appears to have increased slightly (72%) in the mid-1990s. The age at which females become sexually mature has also changed. In the early 1950s the average age at which they matured was 5.8 years, whereas in the early 1980s it was 4.6 years. By the mid-1990s it had increased to approximately 5.6 years. The exact timing of the recent changes cannot be determined since they occurred at a time when few reproductive samples were available. However, they appear to have taken place since the mid-1980s.

Kapel informed the WG that morphometric data on harp seals caught in Greenland in the 1980s are being analysed. They appear to be in general agreement with similar data obtained form Canadian catches, but may be of interest because most of the Greenland samples were collected at a time of the year when information is lacking in the Canadian series (Chabot and Stenson 1996).

3.4.4 Information on the state of the stock

To determine current pup production of Northwest Atlantic harp seals, aerial surveys of the whelping (pupping) concentrations off southern Labrador and/or eastern Newfoundland ("Front") and in the northern and southern Gulf of St. Lawrence ("Gulf") were conducted during March 1999. A total of 5 concentrations were located, two at the Front, one in the northern Gulf, and two closely spaced groups in the southern Gulf (which later joined into one). The northern concentrations were located near traditional areas while the southern Gulf group formed up on suitable ice in the traditional areas, but drifted southward towards Prince Edward Island where they coalesced prior to the survey. Photographic surveys were conducted on all concentrations between 14 and 24 March, while a visual survey was made of the southern Gulf concentrations on 14 March. Photographic counts were corrected for misidentified pups by comparing multiple readings of photographs made by two or more readers. Survey estimates were also corrected for pups absent from the ice at the time of the survey using the occurrence of distinct age-related developmental stages. Multiple estimates were available for two of the whelping concentrations. Pup production was

estimated to be 739,100 (SE=96,300) at the Front, 82,600 (SE=22,500) in the northern Gulf, and 176,200 (SE=25,400) in the southern Gulf (Magdalen Island), thus totalling 997,900 (SE=102,100).

The age composition of catches at the Front and in the Gulf were estimated based on reported numbers of young (0 group) taken and biological sampling of seals one year of age and older (1+) taken from the commercial harvest and research samples. Estimates of the age composition of seals harvested in Greenland obtained from biological samples collected in West Greenland between 1970 and 1993 distinguish young (0 group plus some juvenile) and adults (Stenson *et al*., 2000b, Kapel, this meeting SEA -111).

Pup production and population size of Northwest Atlantic harp seals for the period 1960 to 2000 were estimated using independent survey estimates of pup production, annual estimates of pregnancy rates, and age-structured removals. Removals included reported catch, estimated by-catch, and assumed levels of seals killed but not landed (struck and lost). These data were fit to a three-parameter age-structured population model that allows for differing assumptions of pup mortality. The two parameters estimated in the model are the pup selection parameter (s) and unaccounted mortality (m). The impact of assuming that the mortality of young seals (age class 0) was greater than that of seals one year of age and older (1+) was illustrated by using a fixed parameter (γ) as the ratio of age class 0 mortality to that of older seals. Replacement yields were estimated using differing assumptions of the age structure of the harvest. The uncertainty associated with the estimates was determined by randomly re-sampling from within the sampling error of the pup production estimates.

Assuming that the unreported mortality of age class 0 seals is 3 times that of 1+ animals, the total population was estimated to be approximately 5.2 million, with a 95% confidence interval of 4.0 to 6.4 million seals in 2000. Assuming different γ-values changes the estimates slightly, but differences were minimal. The population was estimated to have increased from less than 2 million in the early 1970s until 1996; since then the population has been relatively stable. Using the current age structure of the removals (~70% young of the year), the 2000 replacement harvest was estimated to be approximately 533,000, with 95% confidence interval (C.I.) 373,000, to 693,000. Assuming that the levels of by-catch and the Greenland harvest remain at their 1999 levels, and accounting for struck and lost, the corresponding replacement level of seals that can be landed in southern Canada at the proportion of pups observed in 1999 (90%) is 257,000; (95% C.I. 102,000, to 342,000). This level would be reduced slightly if the proportion of young in the harvest decreases.

4 HOODED SEALS (*CYSTOPHORA CRISTATA*)

4.1 Stock Identity, Distribution and Migration

It was reported that 4 hooded seals tagged as pups in the Greenland Sea were taken as adults (10+ yr old) during 2000 in the same area; this supports the hypothesis of fidelity to the whelping patch (Øien, this meeting SEA -112). No new satellite tagging has been conducted with this species; however, older data continues to be analyzed including the recent publication of a manuscript summarizing the diving behavior of hooded seals (Folkow and Blix 1999).

A summary of data from hooded seals satellite-tagged by Canadian scientists in the Gulf of St. Lawrence and off Newfoundland (the Front) was presented previously. These results were presented to ICES in 1999 and a manuscript describing the results will be submitted for publication. During July 1998 scientists from Canada and Greenland deployed instruments on 2 juvenile hooded seals in east Greenland (Stenson and Rosing-Asvid, this meeting SEA -114). One animal remained very close to the tagging site for an entire year, while the second animal moved to west Greenland, as far north as Baffin Bay and then returned to southern Greenland by April 1999 when the transmissions ceased.

Since 1996, U.S. scientists from the New England Aquarium (Boston, MA) and National Aquarium (Baltimore, MD) have satellite-tagged and tracked 6 rehabilitated juvenile hooded seals from the time of release. These animals have been tracked to Nova Scotia, Newfoundland, and Greenland waters as far north as Davis Strait.

A genetic study comparing a small number of samples collected from each of the whelping areas is underway in Canada.

4.2 The Greenland Sea Stock

4.2.1 Information on recent catches and regulatory measures

Catches during 1999-2000 (Appendix IV, Table 1) remain well below the sustainable yields identified in the 1998 meeting of the Working Group (ICES CM 1999/ACFM:7; Appendix V, Table 1; 11,200 age 1+ animals). Norwegian catches were 4,446 (including 3525 pups) and 1,989 (1362 pups) seals in 1999 and 2000, respectively. The quotas in both years were 11,200 animals one year old or older (1+ animals). Parts of, or the whole quota, could be taken as weaned pups assuming 1.5 pups equalled one 1+ animal. As in recent years, there were no Russian catches of hooded seals in the Greenland Sea.

4.2.2 Current research

Norwegian scientists are proceeding with studies of hooded seal condition and diet. The ecological importance of hooded (and harp) seals in the Greenland Sea outside of the hunting season is under study with data collected on morphology and diet (stomach contents, fatty acid profiles). Historical and recent (1999) data on biological parameters are under analysis.

4.2.3 Biological parameters

No new information is available, though as noted in 4.2.2, work is beginning on analyses of historical and recent data on biological parameters.

4.2.4 Population assessment

At the 1998 meeting, the question was raised about the potential double counting in the 1997 survey of seals in the breeding patches K04 and K07/K08. At that time, the combined patch (K07/K08) was included in the analysis, subject to further study. In the intervening period, it has been determined that the two patches were indeed the same—the same suckling twins were seen in K04 on 22 March and in K07 on 24 March (Øien, this meeting SEA-112). Therefore, the decision of the 1998 meeting to exclude the K04 from the population estimate is affirmed and the 1998 assessment of 23,762 (95% C.I. 14,819 – 32,705) is confirmed. It must be recognized, however, that this was a minimal estimate of pup production as it excludes pups born outside of the spatial and temporal frame of the survey.

The following parameters were used when assessing the Greenland Sea population of hooded seals using the model of Skaug and Øien (this meeting, SEA-102).

Natural mortality: $M_{1+} = 0.1$, sd. = 0.015.

The M_{1+} value is similar to what has been used in recent assessments of the stock, while the standard deviation is based on the assumption that M_{1+} should be bounded by the assumed interval [0.07, 0.13] (NAFO SCS Doc 83/VI/21).

Pup mortality: $M_0 = 3M_{1+}$ (fixed).

Age specific pregnancy rates: asp(3) = 0.028, asp(4) = 0.262, asp(5) = 0.504, asp(6) = 0.734, asp(7) = 0.802, asp(8) = 0.802, asp(9) = 0.850, asp(10) = 0.908, asp(11) = 0.97 (fixed).

The estimates of reproductive rates were taken from data from the NW stock presented by Hammill and Stenson (2000).

Pup production estimates:

The model was fit to the 1997 estimate of pup production, 23,762 pups (95% C.I. 14,819 – 32,705; Øien, this meeting, SEA-112).

Table 7 Estimated 2000 abundance of hooded seals in the Greenland Sea.

Parameter	Estimate	95% C.I.
1+ population in 2000	102,000	57,000 – 147,000
Pup production in 2000	28,100	16,000 – 40,000
M_{1+}	0.12	0.09 – 0.15
M_0/M_{1+}	3	Fixed
f (birth rate for 1+ females)	0.66	Fixed

The estimated 1+ population size for year 2000 is close to that estimated in the 1998 assessment. The mortality estimated is greater than that assumed in the previous assessment (ICES CM Doc 1999/ACFM:7). However, the confidence interval for M_{1+} is wide, reflecting the fact that the model has difficulty estimating parameters for stocks with a limited number of pup production estimates for the fitting procedure.

4.2.5 Catch options

Catch options are given for current catch levels and sustainable yields.

Table 8 Catch options with corresponding population trend (D_{1+}) for the next 10-year period for hooded seals in the Greenland Sea.

Option #	M_0/M_{1+}	Catch level	Proportion of 1+ in catches	Pup catch	1+ catch	D_{1+}	Lower 95% C.I. for D_{1+}	Upper 95% C.I. for D_{1+}
1	3	Current	16% (current level)	2800	500	1.89	1.07	2.72
2	3	Current	100%	0	3300	1.79	0.95	2.62
3	3	Sustainable	16%	12200	2300	1.00	0.14	1.87
4	3	Sustainable	100%	0	10300	1.00	0.10	1.90

The sustainable catch estimated are similar to those provided in the previous assessment (ICES CM Doc 1999/ACFM:7). The confidence intervals for D_{1+} under the sustainable catches are very large reflecting the uncertainty in the estimate of mortality. The current catch has a low probability of yielding a decline in the population size.

4.3 The Northwest Atlantic Stock

4.3.1 Information on recent catches and regulatory measures

Information presented at the last meeting of the Working Group (ICES CM 1999/ACFM:7) suggested that the total 1998 harvest of hooded seals in Canadian and Greenland waters was approaching the range of replacement yield levels estimated in 1995 (NAFO SCR 95/16), based on 1990 pup productions. However, hooded seal catches in Canadian waters declined from 10,148 in 1998 to 201 in 1999 (Appendix IV, Table 12). Preliminary estimates indicate that catches in 2000 are extremely small.

Recent catches of hooded seals in Greenland waters are presented in Appendix IV, Table 8. The report of catches greater than 9,000 in 1996 received after the last meeting of the Working Group has been confirmed. Catches in 1997 and 1996 declined to 7,500 and 6,328, respectively, which is similar to the levels reported since the 1980s.

4.3.2 Current research

Consumption of prey by hooded seals in the Gulf and off Newfoundland has been estimated using diet data collected off Newfoundland (Hammill and Stenson 2000). Ways of incorporating these estimates into the assessments of commercial fish stocks in the area are being explored. Additional samples are being collected to improve the estimates of diet in these areas.

Morphometric and reproductive data from hooded seals in Newfoundland waters have been collected but have not been analyzed. Additional samples are being obtained whenever possible. Age structure data are being collected during the fishery and scientific sampling programs.

Beyond the satellite tracking of 2 seals in east Greenland (see section 4.1), there is little directed research on hooded seals underway in Greenland waters. A small sample of animals was obtained during a harp seal sampling program. Morphometric, diet, age structure and reproductive data have been collected. Historical data on growth rates is being analyzed.

In Norway, historical data on age, food habits, and morphometrics collected in the Denmark Strait moulting area (see Appendix IV, Table 7) have been entered and analyzed. These results remain to be published.

4.3.3 Biological parameters

Kapel presented preliminary data on standard lengths and mass from some 100 hooded seals collected in SE and NW Greenland waters (1976-1991). These data were also combined with separate data collected in Davis Strait during the 1984 whelping period. The length data were consistent among the different data sets. However, the Davis Strait males appeared to be substantially larger than males from Greenland. The difference may be due to the timing of the collections—the Davis Strait collection was during the whelping period, while the Greenland collections were obtained mainly during the late summer. However, it is also possible that the method of collection resulted in a greater blood loss among the Greenland animals resulting in lower estimates of mass.

Morphometric data are also available from commercial and scientific catches at the Front, and live captures in the Gulf (Hammill *et al*., 1995). Animals in the Gulf appear larger than Front animals although differences in the sampling methods (e.g. blood loss, sample selection) may have produced these apparent differences.

The Working Group suggested that all of the available morphometric data on hooded seals be gathered together and cooperatively analyzed. Data on age/length, morphology, and reproductive status are also available in Norway and Russia and are candidates for this analysis.

4.3.4 Information on the state of the stock

In 1998 and 1999, visual surveys were conducted to estimate pup production in the southern Gulf of St Lawrence which is considered a small proportion of the NW Atlantic population (Hammill, reported by Stenson). The preliminary estimates are in the vicinity of the last published estimate of approximately 2000 from the early 1990s (Hammill *et al*., 1992). It is not known if the lack of ice observed in the gulf in recent years has affected hooded seal production in this area.

No recent estimates of pup production in the other two whelping areas are available. The only estimate of pup production in the Davis Strait was obtained in 1984 (Bowen *et al*., 1987) while the last estimate of production at the Front was from 1990 (Stenson *et al*., 1993). Assessing the current status of this stock will not be possible until more recent estimates of pup production are available. Therefore, the Working Group r**ecommends** that new surveys be

carried out for this stock. Because of the possibility of exchange among the whelping areas (NAFO SCR Doc 95/16), all three areas should be surveyed concurrently.

5 APPROPRIATENESS OF CURRENT AND OTHER POSSIBLE BIOLOGICAL REFERENCE POINTS FOR HARP AND HOODED SEALS

The Working Group was requested to identify B_{lim}, B_{msy} and other reference points and to consider the applicability of these to NE Atlantic harp and hooded seals. Currently, the Working Group provides biological reference points referred to as replacement yield and sustainable yield. Replacement yields are defined as the harvest in year t that will result in $N_t = N_{t+1}$. Sustainable yields are defined as a constant harvest that will result in a stable population within a 10 – 20 year period. The resulting population is usually similar to the current population.

The Working Group noted that the application of a MSY approach to marine mammal management was reviewed and rejected during a joint IUCN and World Wildlife Fund sponsored workshop held at the University of Guelph in 1979 (Anon. 1979). Workshop participants specifically concluded that:

> "… for a number of reasons involving parameter uncertainty and multi-species effects, management based on estimation of maximum sustainable yield (MSY) levels was inappropriate. Replacement yields based on short term projections form a preferable point of reference for management."

The topic was reexamined in 1982 and 1985 at previous ICES Working Group meetings (Anon. 1983; Anon. 1987). The participants came to conclusions similar to those reached at the 1979 meeting.

The Working Group was concerned that B_{msy} may not be appropriate to seal management for several reasons. Inadequate data are available to develop density dependent relationships for harp and hooded seal stocks because seal abundance and productivity are autocorrelated (i.e., adult abundance is derived from surveys of pup abundance). Also, the time series of abundance estimates is brief for seals and does not cover the range of population sizes necessary to determine the functional relationships underlying a B_{msy} approach. Moreover, application of the MSY approach requires an understanding of stock specific population response to ecosystem status (carrying capacity). This relationship is unknown for the stocks considered by the Working Group.

The Working Group reviewed the discussion on B_{lim} presented in Røttingen (2000) as an example of the rationale underlying the application of these reference points to fisheries (Norwegian spring-spawning herring in this case). The use of a specific biomass level below which recruitment is reduced is not applicable to marine mammals. The choosing of biological reference points is dependent upon the management strategy intended. The goals underlying the use of B_{lim} were unclear to the Working Group. Is the desired outcome of the reference point the maintenance of seal populations at or near specific levels or alternatively, are specific harvest levels desired?

The Working Group concluded that with sufficient direction, it was possible that a biological reference point such as B_{lim} was applicable to seal management, but B_{msy} was not.

Other approaches to establishing reference points have been developed elsewhere. The two most prominent are the International Whaling Commission's (IWC) Revised Management Protocol (RMP) and its Catch Limit Algorithm (CLA), and the U.S. Marine Mammal Protection Act's (MMPA) Potential Biological Removal (PBR). Both have clearly defined management goals. The IWC's approach is designed to maximize long term yield while minimizing the likelihood that stock size will fall below a specific level. This includes a central model (the CLA) which is used to define catch limits or yields, and which is surrounded by the control functions of the RMP necessary to implement the harvest regime. The U.S. approach, originally articulated in the 1994 amendments to the MMPA, uses PBR as a biological reference point for yield and the stock's Maximum Net Productivity Level (MNPL) as the reference point for stock size. The PBR model is then designed to define a yield which allows stocks to either remain at MNPL for a prolonged period or alternatively, if the stock is reduced in abundance, allow the stock to rebuild to its MNPL (Wade 1998).

Recognizing the need for a precautionary approach to management of seal populations, the Working Group has taken a cautious approach to estimating reference points whenever possible. Further, it **recommends** the following method for development of biological reference points for seal management:

1. ACFM is requested to provide additional guidance on the goals for seal management.

2. During the proposed population modeling workshop (see section 8) a session will be held to consider the application of density dependent responses to seal management.

3. Risk assessment should be incorporated into the population models applied by the Working Group to seal stocks. The precise form of this assessment remains to be determined, but will likely include the estimation of the probabilities of reaching threshold values or trends, in addition to placing confidence intervals on the abundance estimates.

4. The Working Group should prepare estimates of yield based on alternative biological reference points such as the IWC's CLA and the U.S. PBR approaches for comparison to results from the current models for NW Atlantic harp seals (replacement yield model) and NE Atlantic harp and hooded seals (long-term equilibrium model).

The Working Group proposes that this work be completed in time for the 2002 Working Group meeting, and available for subsequent advice to the ACFM.

6 PREDATION ON COMMERCIALLY IMPORTANT FISH SPECIES BY HARP AND HOODED SEALS

The Working Group considered diet and consumption studies conducted in the Northeast and Northwest Atlantic Ocean on harp and hooded seals.

Prey consumption of the Barents Sea harp seal stock was estimated by combining data on the seasonal estimates of energy density of prey, and energy expenditure and body condition of the seals (Nilssen *et al.*, 2000). Data on diet composition and body condition were collected in 1990-1996 by sampling harp seals during different seasons, in various areas in the Barents Sea. All diet composition data were based on reconstructed prey biomass, and adjustments were made for differences in digestibility of crustaceans and fish.

In 1998, the Barents Sea harp seal stock was estimated to comprise approximately 2.22 million seals based on a mean production of 301,000 pups, which was accepted by the Working Group at the meeting in 1998. The total annual food consumption was estimated to be in the range of about 3.3-5 million tons (depending on the choice of input parameters). The model used different values for the field metabolic rate of the seals (corresponding to two or three times their predicted basal metabolic rate) and under two scenarios: with an abundant capelin (*Mallotus villosus*) stock and with a very low capelin stock.

1. If capelin was abundant, the total harp seal consumption was estimated to be about 3.3 million tons (using the lowest field metabolic rate). The consumption of various commercially important species was as follows (in tons): capelin approximately 800,000, polar cod (*Boreogadus saida*) 600,000, herring (*Clupea harengus*) 200,000 and Atlantic cod (*Gadus morhua*) 100,000.

2. A low capelin stock in the Barents Sea (as it was in 1993-1996) led to switches in seal diet composition, with increased consumption of polar cod (870,000 tons), other codfishes (mainly Atlantic cod; 360,000 tons), and herring (390,000 tons).

The estimates are sensitive to the model assumptions, especially the field metabolic rate. When the field metabolic rate was increased from 2 to 3 times the basal metabolic rate, the consumption estimates increased by approximately 40%.

The Working Group was concerned about small sample sizes, particularly with some extremely fat seals in autumn, which could overestimate food consumption. It was also suggested that the distribution of age groups (or length) of commercial fish species eaten by the seals should be estimated.

Diet data of Greenland Sea harp and hooded seals was collected by Russian and Norwegian researchers during late winter, spring, and early summer during the period 1987-1997 in the Greenland Sea (Haug *et al.* 2000, Potelov *et al.* 2000) and in late autumn in 1999 between Svalbard and Greenland (Haug *et al.*, this meeting, SEA-100). The pelagic amphipod *Parathemisto libellula,* polar cod, and the squid *Gonatus fabricii* were the main prey species for the seals, but none of these are commercially important in that area. Norwegian scientists have started a program aimed to study food consumption by the two seal species in the Greenland Sea.

Based on diet studies from the mid-1980s through the early 1990s, it was reported that commercially exploited fish species were not important for the harp seals in West Greenland waters (Kapel 2000). However, for hooded seals Greenland halibut (*Reinhardtius hippoglossoides*), redfish (*Sebastes* sp.), and in some years cod may be important prey species in Greenland waters.

Prey consumption by grey, hooded, harbour, and harp seals in southern Canadian Atlantic waters was estimated for the period 1990-1996, by bringing together information on individual energy requirements, population size, distribution, and diet composition. Total prey consumption by these pinnipeds increased from 3.1 million to 4.0 million tons over this period. Seventy-seven percent (by weight) of this consumption consisted of fish, with capelin and sand lance (*Ammodytes spp*.) accounting for 49% (by weight) of the total fish consumed. The majority (74%) of total prey consumption occurred off southern Labrador and Newfoundland (Div. 2J and 3KL), followed by the northern Gulf of St Lawrence (Div. 4RS, 18%), and the eastern Scotian Shelf (Div. 4VsW, 4%). In 1996, it was estimated that seals consumed a total of 183,740 tons of Atlantic cod, 83,688 tons of herring, 206,895 tons of Greenland halibut and 134,489 tons of redfish. Harp seals were the most important predator, accounting for 82% of total prey consumption, followed by hooded seals (10% of the total consumption). Regional differences existed in consumption by the seal species: harp seals were most important in Div. 2J and 3KL and in Div. 4RS, hooded seals were most important in Div. 2J and 3KL and Div. 3M (Flemish Cap). Of the 3.1 million tons of fish consumed by the seals, only about 20% was from commercially important species such as Greenland halibut (7%), Atlantic cod (6%), redfish (4%), and Atlantic herring (3%). Most of the consumption of these commercial species consisted of juveniles (Hammill and Stenson, 2000).

Canadian scientists will continue the modelling and incorporate monthly estimates of body mass, variance in the diet data (bootstrapping), and estimate the variance of the food consumption. The Working Group **recommended** that the methods used in the diet and consumption studies should be coordinated, which should be a topic for the 2002 Working Group meeting.

7 ADVICE FOR ACFM

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

8 POPULATION MODELLING WORKSHOP

The Working Group proposes to sponsor a workshop on the modelling of pinniped populations, with a specific focus on North Atlantic harp and hooded seal populations. A subgroup was designated (Merrick, Øien, Stenson) to work by correspondence to develop and carry out the workshop during the winter of 2001-02. Topics of the workshop may include, but not necessarily be limited to:

1. Approaches to the incorporation of density dependence into pinniped models.

2. Use of simulation to test the assumptions implicit in model parameters.

3. Comparison of age-aggregated versus desegregated models, especially under scenarios where the age structure of the catch is highly skewed.

4. Comparison of other modelling regimes (IWC, US) to the current Working Group approach.

5. Modelling of specific problems relevant to management of North Atlantic seals.

It is anticipated that 15-20 scientists will be invited, which will include a mixture of population modellers and biologists representing Canada, Norway, and Russia, plus additional specialists knowledgeable in seal population dynamics from other nations (e.g., Denmark, United Kingdom, and United States). The workshop will likely be 3-5 days long and will include both presented papers and break-out sessions to build and test models. Venue and exact dates for the workshop remain to be determined.

9 FUTURE ACTIVITIES OF THE WORKING GROUP

The Working Group will meet by correspondence during 2001. The next physical meeting is tentatively planned for late summer-early fall of 2002. An invitation by SevPINRO to host the meeting in Arkhangalsk will be discussed by correspondence. The Group will continue to report to ACFM on an annual basis.

Terms of reference may include, but not be limited to:

1. Review of Population Modelling Workshop recommendations.

2. Review of diet and consumption studies.

10 RECOMMENDATIONS

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

1. With respect to the Barents Sea/White Sea:

    a. Analysis of the past and future photographic survey should include estimation of bias due to reader's errors, and further clarification of the methods used to determine the temporal distribution of whelping.
    b. Research on the use of isoline methods for abundance estimation should be continued with the options used for the estimate clearly described when the results are presented.
    c. Tagging of harp seals should be resumed and mark-recapture studies, including testing of the underlying assumptions, should be considered to provide independent estimates of pup production, and results of previous studies should be made available to the Working Group.

2. All available age composition data and biological samples should be analyzed and presented to the Working Group to allow assessment of biological parameters. Sampling should continue.

3. Studies on harp and hooded seal diet with concurrent estimates of prey availability should be continued. The Working Group also recommends that methods and analyses should be coordinated, and that time be devoted to the topic at their next meeting.

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

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

a. Standardizing and improving survey techniques among areas, and
b. Collection of relevant biological data required for population assessments.

6. Hooded seals in the NW Atlantic should be surveyed as soon as possible.

7. Greenland Sea harp seal reproductive data collected by Norway and Russia should be jointly analyzed.

8. Biological reference points incorporating precautionary principles should be established for seal management:

a. ACFM is requested to provide additional guidance on the goals for seal management.
b. During the proposed population modelling workshop (see section 8) a session will be held to consider the application of density dependent responses to seal management.
c. Risk assessment should be incorporated into the population models applied by the Working Group to seal stocks.
d. Estimates of yield based on alternative biological reference points should be made and compared.

11 ADOPTION OF THE REPORT

The report was adopted by the Working Group at 20.15, 6 October 2000.

APPENDIX I

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APPENDIX II

AGENDA

1. Opening Remarks

2. Meeting Arrangements
   - 2..1. Meeting Schedule
   - 2.2 Appointment of Rapporteur(s)
   - 2.3 Review of Terms of Reference
   - 2.4 Adoption of the Agenda
   - 2.5 Review of Documentation

3. Harp Seals (*Phoca groenlandica*)
   - 3.1 Stock identity, Distribution and Migrations
   - 3.2 The Greenland Sea Stock
     - 3.2.1 Information on recent catches and regulatory measures
     - 3.2.2 Current research
     - 3.2.3 Biological parameters
     - 3.2.4 Population assessment
     - 3.2.5 Catch options
   - 3.3 The White Sea and Barents Sea Stock
     - 3.3.1 Information on recent catches and regulatory measures
     - 3.3.2 Current research
     - 3.3.3 Biological parameter
     - 3.3.4 Population assessment
     - 3.3.5 Catch options
   - 3.4 The Northwest Atlantic Stock
     - 3.4.1 Information on recent catches and regulatory measures
     - 3.4.2 Current research
     - 3.4.3 Biological parameters
     - 3.4.4 Information on the state of the stock

4. Hooded Seals (*Cystophora cristata*)
   - 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 Northwest Atlantic Stock
     - 4.3.1 Information on recent catches and regulatory measures
     - 4.3.2 Current research
     - 4.3.3 Biological parameters
     - 4.3.4 Information on the state of the stock

5. Appropriateness of current and other possible biological reference points for harp and hooded seals

6. Predation on commercially important fish species by marine mammals

7. Draft advice for ACFM

8. Population Modelling Workshop
   - 8.1 Remits / Terms of references
   - 8.2 Possible participants, and how do we recruit them
   - 8.3 Organisation

9. Future activities of the Working Group

10. Recommendations

11. Other Business

12. Adoption of Report

APPENDIX III

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APPENDIX IV

CATCHES OF HARP AND HOODED SEALS

INCLUDING CATCHES TAKEN ACCORDING TO SCIENTIFIC PERMITS

Table 1. Catches of **hooded seals** in the Greenland Sea ("West Ice"), 1946–2000[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	36340	825	1063	1888[b]	27563	10664	38228
1961–65	27793	14074	41867	2143	2794	4938	29936	16868	46805
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	1362	623	1989[d]	-	-	-	1362	623	1989[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 figures.

Table 2. Catches of **harp seals** in the Greenland Sea ("West Ice"), 1946–2000[a], incl. catches for scientific purposes.

	Norwegian catches			Russian catches			Total catches		
Year	Pups	1 year and older	total	pups	1 year And Older	total	Pups	1 year and older	Total
1946–50	26606	9464	36070	-	-	-	26606	9464	36070
1951–55	30465	9125	39589	-	-	-[b]	30465	9125	39589
1956–60	18887	6171	25058	1148	1217	2366[b]	20035	7388	27424
1961–65	15477	3143	18620	2752	1898	4650	18229	5041	23270
1966–70	16817	1641	18459	1	47	48	16818	1688	18507
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	7561	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	5610	5945	11555[d]	-	-	-	5610	5945	11555[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 figures.

Table 3. Norwegian **sealing effort** in the Greenland Sea ("West Ice"), 1946–2000[a].

Year	Number of trips/boats	Crew number Total	Crew number Average	Average duration of trips (days)	Average tonnage Gross	Average tonnage Net	Average Horse-Power
1946–50	37	588	16	43	119	42	195
1951–55	45	760	17	40	140	49	277
1956–60	43	702	16	50	137	47	282
1961–65	40	652	16	47	140	48	337
1966–70	24	370	16	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	.	.	.	.	.	.

[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"), 1958–2000[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	.	.	.	.	.
1995–2000[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"), 1946–2000[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	124651			144241
1956–60	2278	14093	15777	58824	34605	93549	61102	48698	109326
1961–65	2456	8311	10761	46293	22875	69168	48749	31186	79929
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	2254	4103	6357[g]	38302	111	38413	40556	4214	44770

[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° E, by one ship which mainly operated in the Greenland Sea.

[g] Preliminary numbers.

Table 6. 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		

[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, 1998 and 1999.

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, 1954–1998.

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

[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 1993–1998 (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		16,244
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	74,945
1997	68,313		1,149		201		69,663
1998	80,712		1,670		109		82,491

[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**	15,464
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"), 1946–2000[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	55957	152981	64995	0	217976
1951-55	184857	87576	0	272433	43542	10697	0	54240	228399	98274	0	326673
1956-50	175351	89617	0	264969	33227	7848	0	41075	208578	97466	0	306044
1961-65	171643	52776	0	224420	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[f]	16	450	0	466[e]	85035	6567	0	91602	85485	6583	0	92068

[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; age class breakdown for Landsmen catch not available yet.

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

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

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

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

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

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

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

Table 12. **Hooded seal** catches off Newfoundland and in the Gulf of St. Lawrence, Canada ("Gulf" and "Front"), 1946–2000[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	612	4457	2405	0	6862
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	12702	613	211	24	848	8096	5430	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	338[d]	0	56	0	56	206	243	0	449
1985	215	220	0	435[d]	5	344	0	349	220	564	0	784
1986	0	0	0	0	21	12	0	33	21	12	0	33
1987	124	4	250	378	1197	280	0	1477	1321	284	250	1855
1988	0	0	0	0	828	80	0	908	828	80	0	908
1989	0	0	0	0	102	260	5	367	102	260	5	367
1990	41	53	0	94[d]	0	0	636[e]	636	41	53	636	730
1991	0	14	0	14[d]	0	0	6411[e]	6411	0	14	6411	6425
1992	35	60	0	95[d]	0	0	119[e]	119	35	60	119	214
1993	0	19	0	19[d]	0	0	19[e]	19	0	19	19	38
1994	19	53	0	72[d]	0	0	149[e]	149	19	53	149	221
1995	0	0	0	0	0	0	857[e]	857	0	0	857[e]	857
1996	0	0	0	0	0	0	25754[e]	25754	0	0	25754[e]	25754
1997	0	0	0	0	0	7058	0	7058	0	7058	0	7058
1998	0	0	0	0	0	10148	0	10148	0	10148	0	10148
1999	0	0	0	0	0	0	201	201	0	0	201	201
2000[f]	2	2	0	4[d]	0	0	10	10	2	2	10	14

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

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

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

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

[e] Statistics no longer split by age

[f] Preliminary estimates

APPENDIX V. SUMMARIES OF SEALING REGULATIONS

Table 1. Summaries of Norwegian sealing regulations for the Greenland Sea ("West Ice"), 1985–2000.

	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]
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]

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

Table 2. Summary of sealing regulations for the White and Barents Seas ("East Ice"), 1979–2000.[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	-	-	-	22,700[6]	17,700	5,000

[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, 1960–2000.

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 condtion of license

Table 3b. Major management measures implemented for hooded seals in Canadian waters (1960–2000).

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 condtion of license.