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Conseil International pour l'Exploration de la Mer

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

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Contents

Executive Summary

The ICES/NAFO Working Group on Harp and Hooded Seals (WGHARP) met during 24-27 August 2009 at the ICES Directorate in Copenhagen, Denmark to consider recent research and to provide catch advice on the northeastern Atlantic Ocean stocks of harp (*Pagophilus groenlandicus)* seals. In attendance were 10 scientists representing Canada, Denmark, Norway, Russia, and United States.

On 24-26 August, the WG received presentations related to catch (mortality) estimates, abundance estimates, and biological parameters of White Sea/Barents Sea and Greenland Sea harp seal stocks, and provided updated catch options in response to a 2008 request from Norway. The WG also received information on the Northwest Atlantic harp seal stock, as well as the Northwest Atlantic and Greenland Sea hooded seal *(Cystophora cristata)* stocks. The WG concluded their meeting the afternoon of 27 August.

A survey of the White Sea/Barents Sea harp seal stock during 14-16 March 2009, and resulted in an estimate of 157,000 pups (SE = 17,000). This estimate is significantly lower than the estimates produced prior to 2004. The WG agreed that the survey appeared to have been carried out very well. There were improvements in the reconnaissance efforts, evaluation of whelping, and survey timing (i.e. closely approximating the dates of surveys flown during 1998-2003). Hypotheses which remain to explain the reduced pup production since 2004 include reduced adult recruitment due to past juvenile mortality, unobserved mortality of adults in recent years, or a shift in contemporary pupping to areas outside of the traditional areas. The high quality of the survey and the availability of recent data on reproductive parameters led the WG to conclude that the stock can now be considered data rich. However, the precipitous decline in pup production after 2003 could not be accounted for by the existing NE model, and as a result the model greatly overpredicted pup production. Because of this, the NE model was considered inappropriate to provide catch options. The only alternative available was to provide sustainable catches option based upon the PBR approach (ICES 2006). Using this approach, the WG estimated that the TAC for the White Sea/Barents Sea harp seal stock should be 30,062 animals.

With respect to the Greenland Sea harp seal stock, new data were collected in 2009 on reproductive rates to supplement the Norwegian survey of pup production carried out during March-April 2007 (110,530 pups with a SE = 27,630). Because these new data are available, the WG considers the stock to be data rich with an abundance greater than N_{LIM}. Therefore, it is appropriate to use a population model to estimate abundance and evaluate catch options. Incorporating the recent survey estimates and reproductive data into the population model used previously produced a population estimate of 810,600 (std 185,030) animals for 2009, or 694,400 (std 165,680) age 1+ seals, and 116,600 (std 21,062) young of the year. Using this model, the WG suggests that a sustainable catch level would be either 49,801 (with a catch including 72,7% pups) or 30,865 (with only 1+ animals caught). Catches at this level will maintain the population at current levels over the next 10 years, while current catch levels (5,247 seals per year) will likely result in an increase in population size of 44% over the next 10 years. Catches 2x sustainable catches will result in the population declining 50% - 60% over the decade.

1 Opening of the meeting

The ICES/NAFO Working Group on Harp and Hooded Seals (WGHARP) met during 24-27 August 2009 at the ICES Directorate in Copenhagen, Denmark to consider recent research and to provide catch advice on the northeastern Atlantic Ocean stocks of harp (*Pagophilus groenlandicus*). In attendance were scientists representing Canada (2), Denmark (1), Norway (4), Russia (2), and United States (1)(Annex 1).

2 Adoption of the agenda

The agenda for the meeting, as shown in Annex 2, was adopted at the opening of the meeting on 24 August 2009.

3 Terms of reference

In February 2008 the Norwegian Royal Ministry of Fisheries and Coastal Affairs requested ICES to assess the status of the stocks of harp seals in the Greenland Sea and White Sea/Barents Sea. The full request is described in ICES (2008), however, a key request was for the WG to:

Assess the impact on the seal stocks in the Greenland Sea and the White Sea/Barents Sea of an annual harvest of:

- *Current harvest levels,*
- *Sustainable catches (defined as the fixed annual catches that stabilizes the future1+ population),*
- *Twice the sustainable catches as defined above*

The request was addressed at the 2008 WG meeting, and the WG provided interim catch advice for the stock. However, the WG was concerned with the uncertainty associated with the White Sea/Barents Sea harp seal survey, and this led the WG to conclude that the stock had to be considered data poor. The WG also recommended that 1) inter-sessional discussions (by correspondence) be held to develop a survey design that could firmly establish whether pup production has indeed declined, and 2) that a March 2009 pup survey be conducted.

The purpose of the 2009 meeting was, therefore, to:

- Review results of intersessional working groups deliberations
- Review results of the White Sea/Barents Sea winter 2009 survey
- Update assessments for White Sea/Barents Sea harp seals based on new data collected in winter 2009 surveys;
- Update assessments of the Greenland Sea harp seals based on new biological parameter data collected in 2008-2009

The WG convened at the ICES Directorate in August 2009 to fulfil this purpose.

4 Harp seals (Pagophilus groenlandicus)

4.1 The White Sea and Barents Sea Stock

4.1.1 Information on recent catches and regulatory measures

Due to concern over the possible reduction in pup production in the White Sea after 2003 and the accuracy of the pup production estimates from 2004 - 2008, ICES (2008) consider the stock data poor, and suggest that catch options should be based on the use of the Potential Biological Removals (PBR) approach. The PBR level of removals in 2009 would be 21,881 animals in the White and Barents Sea, assuming that the age structure of the removals is proportional to the age composition of the population (i.e. 14% pups). A catch consisting of a higher proportion of pups would be more conservative. In order to continue the development of hunting activities in the White Sea, the Joint Norwegian-Russian Fisheries Commission suggested that the TAC for 2009 should be set at a higher level, 35 000 seals. Based on this quota, Russian sealers planned to use the new boat-based approach introduced in the White Sea catch in 2008. This catch, using ice class vessels fitted with small catcher boats, would focus primarily on weaned pups (beaters). No white-coats would be taken. However, shortly before the hunt began, the Russian government implemented a ban on the catches of breeding females and all White Sea harp seals under one year of age. As a result, there were no Russian harp seal catches in the White Sea in 2009. Also, no Norwegian vessels operated in the southeastern Barents Sea in 2009. (Haug and Zabavnikov, SEA 181).

From a scientific point of view there is no doubt that the Barents Sea / White Sea harp seal stock can be sustainably harvested according to the advice provided by ICES, but the working group is concerned over the nearly 60% increase of the TAC that was decided upon.

4.1.2 Current research

In previous studies of Barents Sea harp seals, observations have indicated that poor condition of juvenile and adult seals could be linked to reduced recruitment to the stock. In a Norwegian sampling program conducted during April/May in 1992-2006 onboard Norwegian sealers operating in the southeastern Barents Sea (the East Ice), body condition data were collected from a large number of juvenile and adult harp seals. The data were analyzed to determine if there are some year-to-year variations, in particular if there are some changes after 2003 when the possible decline in recruitment to the stock could have occurred (Øigård *et al*., SEA 182).

No difference was observed between sexes in body weight or body condition in any of the sampling periods. The mean body weight of pups showed a significant year-to-year variation in 1992 – 2006. However, no significant changes in body condition index or blubber thickness of pups were found throughout the study period. For mature adult seals (i.e. seals larger than 150 cm) and 1+ animals in general, a significant drop of body weight, condition index, and blubber thickness were observed in 2006 compared to previous years. Both the condition index and the blubber thickness showed an increasing trend in both adults and 1+ animals during the period 1992-2001.

During the massive invasions of harp seals (primarily Barents Sea/White Sea seals) to the coast of Norway in 1986-1988, seals were reported to be in very poor condition. It was suggested that the invasions resulted from food shortage due to the simultane-

ous low abundance of three key pelagic forage fish species: capelin (*Mallotus villosus*), herring (*Clupea harengus*), and polar cod (*Boreogadus saida*). The Barents Sea capelin has undergone drastic changes in stock size during the last three decades with collapses in 1985-1989, 1993-1997 and 2003-2006. Although variations have occurred, it seems as if the availability of forage fishes may have improved in the Barents Sea in the 1990s as compared with the late 1980s; the period 1997-2001 was characterized by increased abundance in all three key prey species in the Barents Sea. The current analyses suggest that this is also a period of stable or even improved, condition in harp seals. The period after 2001-2006 is characterized by a new collapse in the capelin stock, whereas the abundance of both polar cod and herring were good. Unfortunately, the 2006 data showing an apparent decline in condition, are the only available on Barents Sea harp seal condition in the period between 2001 and 2009. Currently, the polar cod population seems to be in good shape and the capelin stock size has improved substantially in the last two years. How these recent changes may have affected the general condition of harp seals in the area is not known. To address this question, new samples are required. Sampling from commercial catches in the southeastern Barents Sea in April-May 2010 is highly recommended.

Previous research, carried out primarily in the Northwest Atlantic during the 1980s, indicated strong sex, seasonal and spatial separation of age/sex classes in the moulting patch, and also a rapid mass loss at this time of year (Chabot and Stenson 2002). More detailed analyses on the White Sea data should consider analyzing the date of sampling, perhaps in 2 week blocks, to see if observed mass, blubber thickness and condition changes were linked to timing of sampling rather than reflecting interannual differences. The data were analysed as pup, 1+ and adult categories based on lengths. Condition changes are expected to occur first among juveniles. If possible, and realizing that there are errors associated with separating animals into age class groups based on length, separating animals into young of the year, juveniles and adults for condition/blubber thickness changes might be examined. However, even considering these caveats, Øigård *et al*. (SEA 182) suggests that there were marked declines in condition in 2006.

4.1.3 Biological parameters

Samples of harp seal teeth (for ageing) from the Norwegian moulting catches in the southeastern Barents Sea have been collected since 1963. Kjellqwist *et al*. (1995) presented age distributions in the catches for the period 1978-1993, while Øien and Hartvedt (SEA 191) presented age distributions from the Norwegian catches in 1994-1998 and 2006. Sampling periods have typically been from end of March until beginning of May. There are currently high mean ages in the samples both for males and females. In fact, the mean ages in the moulting samples have approximately doubled over the past 30 years. For the years 1994-1997 the distributions were dominated by the cohorts born from the late 1970s up to 1985, the latter cohort forming a prominent peak starting in 1995. In 1994 the 1983 cohort was the most abundant. As in previous presentations of age samples from the Barents Sea harp seal population after the seal invasions along Norwegian coastlines 1986-1989 (peak in 1987) that indicated a nearly complete loss of cohorts from these years, the 1987 cohort was barely found in these 1994-1997 samples. However, in the 1998 sample, the 1987 cohort starts to contribute to the age distribution and is still an important contributor in 2006, where in fact all the "seal invasion" cohorts are important contributors during the years with high total pup production in the White Sea. Thus one explanation of their reappearance may be that these cohorts chose another strategy than the assumed usual migra-

tion paths taken by the population. Observing that the 1987 animals showed up again after 10 years, may support non-permanent emigration, although there is no indication where they may have spent the intervening time.

The age distributions in Øien and Hartvedt (SEA 191) provide an indication of strong year classes. The 1992 cohort showed strongly up in the 1995 sample and is found as a prominent peak in the following years' distributions. The 1997 cohort does not seem to have made it equally well, but judging from the 2006 sample, both the 1993 and 1995 cohorts are strong.

In earlier work, Øien and Øritsland (1995) proposed that some of the changes in age class strengths represented delayed recruitment of 'seal-immigration' cohorts into the Barents Sea-White Sea moulting patch. However, it is unclear if some of the inter-annual differences may reflect changes in harvest strategies. Although the same Norwegian ships have been used for 40 years, there were efforts to harvest older males for the penis industry in the 1990s, although this no longer appears to be occurring. There was some concern that the mean age in the samples showed a strong increase from around 6 years old to 14 years old, this high mean age in the sample may reflect the absence of young animals in the population.

4.1.4 Population assessments

During the 2008 meeting 4 hypotheses were identified as possible explanations for the dramatic decline in pup production estimates observed in the White Sea since 2004 (ICES 2008).

- Timing of survey too late and therefore pups had entered the water
- Pups may have been lost before the survey (either due to bad ice or drifting out of the survey area)
- Declining female reproductive rates
- Major increase in adult female mortality

The first two of these hypotheses would have resulted in an underestimate of total pup production, while if either of the latter two hypotheses were correct, the surveys would have accurately reflected pup production. The Working Group recommended that new surveys be conducted in 2009 and that the timing of the surveys be earlier in the season. Also, it was suggested ice conditions be monitored and that the interpretation of photos should be compared among experience readers from the surveying nations.

Photo comparisons

A workshop to compare methods of reading aerial photos from harp seal pup surveys was held on 25-29 May 2009 at PINRO in Murmansk (Øigård *et al.*, SEA 180). Readers from IMR and PINRO exchanged photos and used their own methods on the other group's photos. IMR provided photos taken during a survey in the Greenland Sea in 2007, and PINRO provided photos taken from a survey carried out in the White Sea in March 2009.The photos used by IMR have very high resolution and are of good quality. This makes it easy to spot the white pups in general, although pups lying in shaded areas can still be difficult to spot. The photos used by PINRO had lower resolution than those used by IMR. However, in parallel with the digital photos, PINRO used full IR images, and this tool greatly enhanced the detection rate. IMR readers examined the photos using Adobe Photoshop, and the pup positions were recorded on a digital overlay. PINRO readers examined the photos using a spe-

cial software module, prepared and developed by PINRO using the MATLAB software. The analysis demonstrated that PINRO readings of the IMR photos had a systematic underestimation of the number of pups. This may be due to the lack of features in the Matlab software which would have allowed the PINRO readers to adjust of images (something which is done routinely by IMR readers using Photoshop). Also, the PINRO readers did not have access to IR images when reading the IMR photos. There were no significant differences between the IMR readings of the PINRO photos and the original (i.e. photos + IR imagery) PINRO readings. Thus, the IR imagery appear to compensate for the lack of tuning possibility in their software. It was concluded that both groups appear to have satisfactory, and comparable, methodologies for analyzing the aerial photos.

The Working Group noted that the study was a very interesting one and was well done. It was suggested that it would be useful to have a Norwegian reader gain experience with the PINRO photos and then read a selection of photos using the Matlab software program to determine if the differences are a result of the readers or the software systems (e.g., does the use of the Photoshop software make a difference?) The Matlab program used by the Russians worked well, but some improvements to allow changing colours, brightness and contrast were suggested. Comparisons with Canadian readers would also be worthwhile.

The development of automated image detection software is being investigated. Some earlier work has shown that it is difficult for an automated system to detect white pups on a white background. However, the approach would be valuable, if only to eliminate photos that did not have seals on them.

Pup production

Pup production estimates based on multispectral survey data (infrared [IR] and digital RGB imagery) from aerial surveys flown during 14-16 March 2009 were presented by Zabavnikov and Shafikov (SEA 187). The total pup production estimate was 157 000 (SE=17 000). This value is slightly higher than in 2005 and 2008, but still less than observed in 2004 and in 2000-2003.

Prior to the multispectral survey, reconnaissance flights were conducted in the entire White Sea area on 6 and 11 March. During these flights, observations were made of ice condition, localization of main breeding patches, and the progress in breeding activity. Very active whelping (determined by the presence of extensive blood on the floes) was observed on 6 March, while little fresh blood was observed on the floes on 11 March. Thus, it was assumed that the starting date of the survey (14 March) was after the peak of pupping.

Highest pup density was recorded in the east-central region of the White Sea "Basin" close to the Kola Peninsula south coast. In other areas of the White Sea densities were much lower, and in adjacent southeastern areas of the Barents Sea (outside Cheshskaya Bay) only very scattered adults with pups were observed.

The ice conditions in 2009 were considered better for harp seal whelping than in 2008, and closer to the situation observed in 2003-2005 when reductions in total pup production were first recorded. The entire survey period was characterized with calm, stable winter weather which was very beneficial for the activities.

Generally, track lines were flown in areas with ice concentrations between 70-90 %, and with a transect spacing of 7.5 km. No direct satellite monitoring of ice drift was conducted, but based on information from the Arkhangelsk Hydro-meteorological Center ice drift was assumed to be low.

As in 2008, walruses were observed in the harp seal whelping patches also in 2009, presumably feeding on pups. The icebreaker activity observed in the area in previous years which was considered to a potentially important source of mortality did not occur in 2009.The shipping route was changed as a result of efforts by PINRO Arkhangelsk Hydro-Meteorological Center and the World Wildlife Fund so that ships passed to the south and around the harp seal whelping patches.

The WG agreed that the survey appeared to be a good survey. There were improvements in the reconnaissance efforts, evaluation of whelping, and the timing of the flights was earlier, (i.e. closely approximating the dates of surveys flown during 1998-2003, see table). A more complete area was surveyed more quickly which minimized the potential for drift (double counting) or loss of significant numbers of animals from the area. Also, the weather was favourable in 2009. However, the WG noted that it would be helpful to place satellite linked beacons at different locations on the ice to monitor actual drift, particularly since difference areas may move at different rates and to monitor the movements of individual concentrations of animals.

The WG also noted that it would be helpful if maps indicating the flight lines of both the reconnaissance and transect surveys, and the actual numbers of seals seen on each line, were provided in the working paper. Although whelping activity appeared to be low on 11 March, this was based on qualitative information. The proportion of pups in different developmental stages should be obtained from on-ice surveys carried out throughout the survey period. At a minimum, actually counting fresh blood spots on the ice, or attempting to count the number of newborns on photos and contrasting this with the numbers of older pups would also help to provide some quantitative evaluation of the season of births. The possibility of seals pupping in regions outside of the survey area was discussed, but these areas appeared to be covered by fast ice, or heavy ice, so it is unlikely that seals were present. These regions include to the west of 45 degrees east, the southern portion of the White Sea and portions of Cheshskaya Bay and the coastal areas of the Barents Sea. Although densities were very low in the northern part of the White Sea, there were some animals near the ice edge that opened to the Barents Sea suggesting that there could be some loss, but this was thought to be minimal in 2009. However, the WG recommended that reconnaissance efforts in the north be increased to include new areas, particularly in poor ice years since seals may whelp elsewhere under these particular conditions.

Table 1. Timing of Russian surveys, estimated numbers of pups and coefficients of variation (CV) in the White Sea/Barents Sea. Numbers and CVs are drawn from original working papers presented to WGHARP.

Year	Survey Period	Estimated Number of Pups	Coefficient of Variation
1998	12 & 16 March	286,260	0.150
2000	10-12 March - photo 18 March -multispectral	322,474[c] 339,710[b]	0.098 0.105
2002	20 March	330,000	0.103
2003	18 & 21 March	328,000[a]	0.181
2004	22 March – photo 22 March - multispectral	231,811 234,000	0.190 0.205
2005	23 March	122,658	0.162
2008	19-20 March	123,104	0.199
2009	14-16 March	157,000	0.108

a. 2003 estimate represents the sum of 298,000 pups (SE = 53000) counted, plus a catch of 35,000 prior to the survey for a total pup production of 328,000

b. Second 2000 estimate represents the sum of 308,981pups (SE = 32,400) counted plus a catch of 30,729 prior to the survey for a total pup production of 339,710

c. First 2000 estimates represented the sum of 291,745 pups (SE = 28,708) counted plus a catch 30,729 prior to the survey for a total pup production of 322,474

As a result of the 2008 survey, the working group felt that the reduced pup production observed since 2004 does not appear to be a result of poor survey timing, poor counting of imagery or the disappearance of pups from the survey areas prior to the survey. The remaining possibilities to account for the reduced pup production since 2004 include reduced adult recruitment due to past juvenile mortality, unobserved mortality of adults in recent years, or a shift in contemporary pupping to areas outside of the traditional areas. During the late 1980s or early 1990s, some reports of harp seal pups being observed in Svalbard were received. Therefore, the WG felt that it was important that areas in the northern and southeastern Barents Sea and Kara Sea be searched during future surveys.

Population estimates

Based on current data availability and the criteria agreed to previously (3 surveys within the past 15 years, one survey within the past 5 years, recent data on reproductive rates), the Working Group considered the Barents Sea / White Sea harp seal population to be data rich.

Korzhev (SEA 189) presented results from mathematical modelling designed to estimate total population abundance. The estimations were performed using a cohort model allowing for uncertainty in model parameter estimation using Bayesian stochastic analyses and a production model based on the Schaefer's equation of logistic production growth (in practical terms the former is the same as the model previously used by the working group for assessment of NE Atlantic seal populations, see ICES 2006). The results of the various model runs suggested a population size in the range of 1.1 – 1.3 million animals.

The working group had serious concerns about the use of the production model, which was based upon historical estimates of total abundance obtained prior to 1998 (the start of the pup production surveys). The methods used to obtain many of these

estimates is not known while others were obtained from counts of breeding females which the WG had previously considered unreliable.

Although the methods used for the Bayesian analysis are considered appropriate for modelling the population dynamics of seals, the working group concluded that this model was unable to capture the sudden drop in pup production in the White Sea observed after 2003. The fit to the observed survey data was extremely poor and the predicted estimate of 2009 pup production was unrealistic (~30% higher than the survey estimates). Therefore, it concluded that neither of these models provided adequate estimates of current and historic abundance that will allow us to understand the population dynamics of this population. However, it was agreed that these models do provide an approximately multiplier that can be used to scale the pup production in order to obtain an approximate population size. Using a multiplier of 7, a population estimate of 1,099,000 was obtained.

The current model uses a constant maturity ogive over the entire time period. Considering the changes observed in reproductive rates in this population, the WG recommended that the existing model be modified to allow for non-constant reproductive rates. It also suggested that mortality associated with the poor condition and seal 'invasions' of the mid 1980s and 1995 be incorporated into the model to determine if changes in the age structure associated with these poor cohorts may have an impact on the current population.

Alternative methods to estimate pup production and the total population were presented in Shafikov (SEA 188) and Shafikov (SEA 190), respectively. However, the working group did not feel qualified to evaluate the methods based upon the working papers submitted without the presence of Dr. Shafikov who was not able to attend the meeting.

4.1.5 Catch options

Because the models presented in SEA-189 were not considered appropriate, the working group felt that they could not be used to provide catch options. The only alternative available was to provide sustainable catches option based upon the Potential Biological Removal (PBR) approach (ICES 2006).

The Potential Biological Removals has been defined as:

$$PBR = 0.5*R_{max}*Fr*N_{min},$$

where R_{max} is the maximum rate of increase for the population, Fr is the recovery factor with values between 0.1 and 1, and N_{min} is the estimated population size using 20th percentile of the log-normal distribution. R_{max} is set at a default of 0.12 for pinnipeds. Because the size of the White Sea / Barents Sea harp seal stock was considered to be somewhere between N_{30} and N_{50}, and given the still unexplained drop in pup production observed beginning in 2004, the recovery factor Fr was set to 0.5. Using the CV = 0.11 obtained from the pup production estimate, N_{min} was estimated to be 1,002,061. Using these figures, the PBR level of removal was estimated to be 30,062 animals in the White and Barents Sea.

This assumes that the age structure of the removals is proportional to the age composition of the population. It is estimated that the current composition of the population includes 14% pups. A catch consisting of a higher proportion of pups would be more conservative.

4.2 The Greenland Sea Stock

4.2.1 Information on recent catches and regulatory measures

The 2009 TAC for harp seals in the Greenland Sea was set at 40 000, i.e. very close to the removal level recommended by ICES as the level that would stabilize the population at present level: 40,383 animals, assuming that the age structure of the removals is proportional to the age composition of the population (currently 14% pups) - a catch consisting of a higher proportion of pups would be more conservative (ICES 2008). Available information on Norwegian catches of harp seals in the Greenland Sea pack-ice in 2009 is listed in Annex 7, Table 1. Russia has not participated since 1994. The total catch was 8,035 (including 5,117 pups). The number of participating vessels in the Greenland Sea in 2009 was 3, whereas removals were 20% of the identified sustainable level (Haug and Zabavnikov, SEA 181).

4.2.2 Current research

Frie (SEA 186) presented the results of a transatlantic image-based blind reading experiment on known-age harp seals carried out in 2006. Generally the experiment showed high accuracy and precision in age determinations of 1-7 year-old seals and increasing underestimation in seals aged 8-18 years. For the young seals, highly experienced readers were generally more precise and accurate than less experienced readers, although exceptions did occur. Some readers showed clear positive bias in age determinations of young seals, while negative bias was not seen. The slopes of regression lines describing bias in older seals differed significantly between readers and showed no clear association with reader experience level. The smallest bias was seen in the only reader with extensive known-age training on teeth from older seals. A subset of teeth was read, both as images and original sections, by 5 readers. Comparisons showed no significant effect of format. This suggests that the exchange of images can be a useful tool for calibration of readings between laboratories.

4.2.3 Biological parameters

Frie (SEA 185) presented new reproductive data for Greenland Sea harp seals. Mean age of maturity (MAM) was estimated at 7.6 years for a sample of 231 Greenland Sea harp seals collected during the early moulting period in 2009. This is significantly higher than the long term average of 5.6 years estimated for the period 1964-1990, but not significantly different from estimates for 1991 (6.9 years) and 2000-2008 (7.0 years). The 2000-2008 sample was relatively small (N=84) and biased towards females with adult pelages, which may have caused a negative bias in MAM. However, the new estimate based on a larger and unbiased sample, indicates that there has been a general increase in MAM of Greenland Sea harp seals.

The higher value of MAM may indicate a significant reduction in per capita resource levels due to either increasing population size or extrinsic changes in food availability. If this is the case, the effect appears to target maturity as the post 2000 estimates of ovulation rates (96-99%) and pregnancy rates (80-81%) of mature females did not differ significantly from previous estimates for the period 1964-1991. Comparisons with 2006 reproductive parameters for the Barents Sea/White Sea stock (BS/WS stock) show no significant difference between the two NEA stocks in MAM, although the recent pregnancy rates estimated for the Greenland Sea stock was significantly higher than the most recent estimate for the BS/WS stock (68%) based data from 2006.

4.2.4 Population assessment

Previously the Working group considered the Greenland Seal harp seal population as data poor due to the lack of recent reproductive data. However, with the additional data presented at this meeting (Frie, SEA 185) the working group now consider the Greenland Sea harp seal stock data rich.

The population model

The model used to assess the abundance for Greenland Sea Atlantic harp seals was the same as that presented and used at the 2005 WGHARP meeting (ICES, 2006). The population model estimates the current total population size using historical catch data and estimates of pup production. In principle, the model can also estimate biological parameters (M1+, M0 and F), but for the population to which the model is applied there is not enough data to provide accurate estimates of M1+ and M0. To compensate for the lack of data, information from other similar populations was used as input to the model in the form of a prior distribution (mean and standard deviation) for each of M_{1+}, M_0.

The parameters of the model are:

$N_{0,t}$ = number of pups born in year t,

$N_{i,t}$ = number of individuals at age i in year t,

N_{1945} = Population size in 1945,

M_0 = pup mortality,

M_{1+} = Mortality among 1+ animals,

$p_{i,t}$ = proportion of females at age i being reproductively active in year t

F = Natality rate (i.e. proportion of mature females giving birth)

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

$$N_{i,t_0} = N_{1945} \cdot e^{-(i-1)M_{1+}} M_{1+} \left(1 - e^{-M_{1+}}\right),$$

and

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

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

$C_{0,t}$ = Catch in number of pups born in year t,

$C_{i,j}$ = Catch in number of individuals at age i in year t.

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

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

.

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

$$N_{1,t} = (N_{0,t-1} - C_{0,t-1})e^{-M_0},$$

$$N_{i,t} = (N_{i-1,t-1} - C_{i-1,t-1})e^{-M_{1+}}, \quad i = 2,\ldots,A-1$$

and

$$N_{i,t} = \left[(N_{A-1,t-1} - C_{A-1,t-1}) - (N_{A,t-1} - C_{A,t-1})\right]e^{-M_{1+}},$$

The pup production is given as

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

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

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

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

and the depletion coefficient:

$$\mathrm{D}_{1+} = \frac{\mathrm{N}_{2019,1+}}{\mathrm{N}_{2009,1+}}.$$

The estimated parameters are N_{1945} (the population size in 1945) along with the biological parameters M_{1+}, M_0 and F. These are found by minimizing an objective function consisting of the weighted (according to survey standard deviation) sum of squares of the differences between the model value and the survey estimates of pup production. A penalty term resulting from the assumed (normal) priors on M_{1+}, M_0 and F is also added to the objective function. To minimize the total objective function the statistical software AD Model Builder (http://otter-rsch.com) is used. AD Model Builder calculates standard deviations for the model parameter, as well as the derived parameters such as present population size and D_{1+}.

4.2.5 Population estimates

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

Age at maturity ogive:

Table 2. Estimates of proportions of mature females (p) at ages 4-13. From Frie (SEA 185).

Age	4	5	6	7	8	9	10	11	12	13
p	0.003	0.06	0.28	0.55	0.76	0.88	0.95	0.98	0.99	1.00

Table 3. Estimates of Greenland Sea harp seal pup production. From ICES (2006), and Øigård *et al.* (2009). Note that the 2007 estimate was revised from that presented in ICES (2008).

Year	Estimated Number of Pups	Coefficient of Variation.
1983	58,539	0.104
1984	103,250	0.147
1985	111,084	0.199
1987	49,970	0.076
1988	58,697	0.184
1989	110,614	0.077
1990	55,625	0.077
1991	67,271	0.082
2002	98,500	0.179
2007	110,530	0.250

When the model was run with precise (i.e. informative) priors, the results tend to reflect the initial starting conditions. However, when the model was run with uninformative priors (i.e. larger SDs), the results converge regardless of the initial conditions. Given our uncertainty in these parameters, we agreed to use uninformative priors.

The prior distributions for M_{1+}, M_0 and F are given in Table 4. The mean of the prior for M_0 was taken to be approximately three times that of M_{1+}. The estimated population is presented in Table 3, and the population trajectories can be found in Fig. 1. Several mark-recapture studies conducted during the 1983-1991 period produced quite variable estimates of pup production (Fig. 1). The model gave greater weight to the 1983-91 pup production estimates with smaller standard errors when fitting to the data. The estimate of the harp seal abundance in the Greenland Sea in 2009 was 810,600 (std 185,030) seals with 694,000 (std 163,680) 1+ year old seals and pup production of 116,600 (std 21,062).

The 2007 population was estimated to be 756,200 (std = 105,318) at the 2008 WG meeting (ICES, 2008), and 752,600 in the current analysis. This suggests the current model fits as well as the previous model.

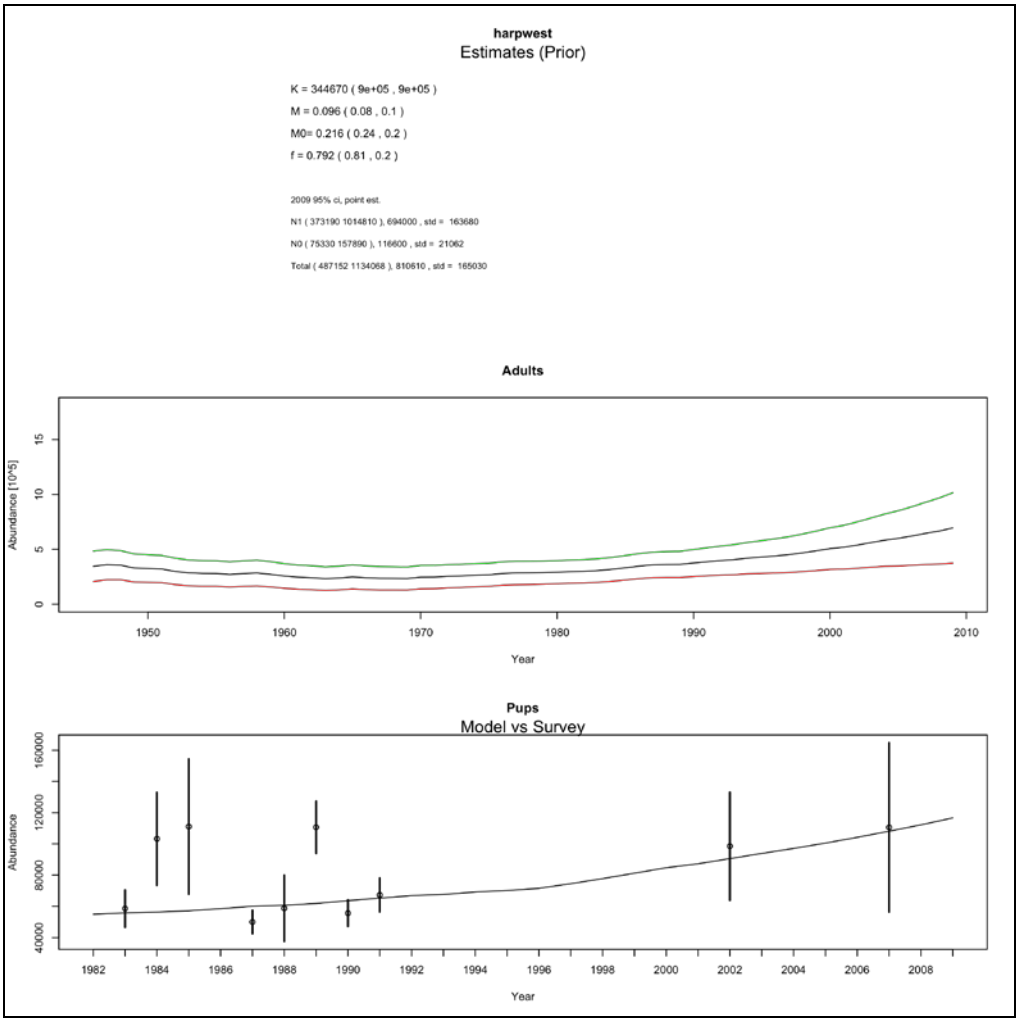

Figure 1: Estimated model and model diagnostics for harp seals in the Greenland Sea. Top Panels: Estimated N population trajectory with 95% confidence limits. Lower panels: Modeled pup production (solid line) and 95% confidence intervals (vertical bars) for available pup production estimates (dots).

Table 4. Estimated status of harp seals in the Greenland Sea during 2009. The column "Estimate" shows the estimated parameters (point estimate and standard deviations), while the column "Prior" shows the prior distributions placed on parameters.

Parameter	Estimate		Prior	
	Est.	SD	Mean	SD
M_{1+}	0.096	0.010	0.08	0.1
M_0	0.216	0.084	0.24	0.2
F	0.792	0.049	0.79	0.2
$N_{1+}(2009)$	694,000	165,680		
$N_0(2009)$	116,600	21,062		

The Working Group noted that the current model applies a constant reproductive rate for all years. Given the changes in reproductive rates observed for the population, the WG recommends that the model be modified to allow for changes in reproductive rates over time. The impact of the selection of priors and associate variance should also be explored further.

4.2.6 Catch Options

Since this population is now considered to be data rich, the population model described above was used to provide catch options. Options are given for various catch scenarios described below.

- Current catch level (average of the catches in the period 2005 – 2009).
- Sustainable catches.
- Two times the sustainable catches.

The sustainable catches are defined as the (fixed) annual catches that stabilize the future 1+ population under the estimated model. The catch options are further expanded using different proportions of pups and 1+ animals in the catches.

The estimates for the various catch options are given in Table 4. Sustainable catches are 49,801 (72,7% pups) or 30,865 (100% 1+ animals).

Current catch level will likely result in an increase in population size of 44% over the next 10 years, whereas catches 2x sustainable catches will result in the population declining by approximately 50% - 60%.

Table 5. Catch options with relative population size (D1+) in 10-years (2019) for harp seals in the Greenland Sea.

Option #	Catch level	Proportion of pups in catches	Pup catch	1+ catch	Total catch	Relative population size (D1+)		
						Lower CI	Point estimate	Upper CI
1	Current	72.7% (current level)	3,814	1,433	5,247	1.17	1.44	1.71
2	Sustainable	72.7%	36,205	13,596	49,801	0.61	1.00	1.40
3	Sustainable	0%	0	30,865	30,865	0.66	1.04	1.42
4	2 X Sustainable	72.7%	72,410	27,192	99,602	0.00	0.50	1.06
5	2 X sustainable	0%	0	61,730	61,730	0.06	0.60	1.13

4.3 The Northwest Atlantic Stock

4.3.1 Information on recent catches and regulatory measures

Recent catches and quotas in Canada were presented by Stenson (SEA 193,). The current 5-year management plan began in 2006 with a Canadian commercial quota of 325,000. An additional 6,000 seals were identified for a special Aboriginal hunt initiative and 2,000 seals were allocated for the Personal Use hunters and Arctic catches resulting in a total Total Allowable Catch (TAC) of 335,000. To ensure that the popu-

lation was maintained above the Precautionary Reference Level of N70 (Hammill and Stenson 2007) and concerns about poor ice in the southern Gulf of St. Lawrence, the TAC was reduced in 2007 to 270,000. The TAC was raised slightly to 275,000 for the 2008 hunt, as a result of low catches the previous year and further raised to 280,000 in 2009 due to an additional allocation to Quebec hunters in the Gulf to seals for market development.

A total of 354,867 harp seals were reported taken by commercial hunters in Canada during 2006 (Annex 7 Table 3). This exceeded the TAC by 6% although this assumes that 2,000 seals were taken in the Canadian Arctic which double the level assumed to occur by Stenson (2005). Catches were significantly reduced in 2007 (224,745, 83% of TAC) due to the lack of ice in the southern Gulf and heavy ice off Newfoundland. Poor ice, offshore distribution and low prices also resulted in lower catches in 2008 with only 79% (217,850) of the TAC taken. Catches in 2009 were extremely low, totalling only 72,407 seal (26% of the TAC). This was primarily due to reduced effort owing to the low prices offered.

Data on catches in Greenland are usually available 1 to 2 years after the harvests. At previous meetings there has been concern that high harvests in the Canadian commercial harvest were having an impact on harvest levels in the Greenland hunt. The most recent statistics (Annex 7 Table 3) indicate that Greenland harvests during 2005-2007, the most recent reporting years, are above the long-term average. Catches of Northwest Atlantic harp seals in 2007 were reported to be 82,778. This would suggest that the high Canadian harvests did not have an impact on the Greenland harvest.

No new data are available on catches of harp seals in the Canadian Arctic. However, catches appear to be relatively low and a recent study indicates that current catches average less than 1,000 per year (Annex 7 Table 5).

Stenson (2008) estimated human induced mortality of harp seals in the northwest Atlantic. In addition to reported catches, he estimated the number of seals killed as bycatch in fishing gear (Newfoundland bycatch and US Atlantic fisheries) and seals killed but not landed or reported (i.e. 'struck and lost'). Using this approach, the average total removals from 1952 – 1982 was approximately 388,000, but declined to 176,000 per year between 1983 and 1995. Between 1996 and 2004, higher catches in Canada and Greenland resulted in average annual removals of 468,500. Owing to the lower catches in Canada, total removals in 2009 was estimated to be approximately 239,500 (Annex 7 Table 7).

Given the reduced level of catches in Canada during the past two years, the high level of hunting in Greenland (including struck and loss) and the relative ages of seals taken in the two hunts, the current Greenland hunt may be having as great, or possibly even greater, impact on the population dynamics of Northwest Atlantic harp seals than the hunt in Canada.

4.3.2 Current research

Research on diet, reproductive rates, growth, condition and habitat use are continuing. Estimates of recent diets, consumption and preliminary results of a model exploring the importance of harp seals and capelin on the population dynamics of Atlantic cod (*Gadus morhua*) were presented at a workshop on the impact of seals on Atlantic cod, held in Halifax, Canada in 2008. The proceeding of this workshop should be available on the web soon.

4.3.3 Biological parameters

No new data were presented. An update on recent reproductive rates is expected to be available later this year.

4.3.4 Population Assessment

Analysis of the 2008 harp seal survey has not been completed. It is expected to be completed and undergo peer review later this year.

5 Hooded seals (*Cystophora cristata*)

5.1 The Greenland Sea Stock

5.1.1 Information on recent catches and regulatory measures

Concerns over low pup production estimates resulted in a recommendation from ICES that no harvest of Greenland Sea hooded seals should be permitted, with the exception of catches for scientific purposes, from 2007 on (ICES 2006b). This advice was immediately implemented. Total catches for scientific purposes (all taken by Norway, Russian sealers did not operate in the Greenland Sea) in 2009 were 413 (including 396 pups) (Annex 6, Table 1). (Haug and Zabavnikov, SEA 181)

5.1.2 Current research

In 2007-2008, materials for a project on the evaluation of reproduction, contaminant loads and general health status of Greenland Sea hooded seals were collected, and the project is presently being evaluated for funding by the Norwegian Research Council. Further sampling will be conducted in July 2010 when a minimum of 200 adult hooded seals will be collected.

A scientific take of 396 bluebacks in 2009 (originally planned to be 200 weaned bluebacks early in the season and 200 new bluebacks late in the season) was performed to continue a time series, started in 1995, where condition of bluebacks (weights, measurements, blubber thickness) was measured at fixed time windows during the Greenland Sea hunt. Data are available from several subsequent years (all samples taken from the commercially hunted pups) - new samples in 2009 allowed extension this time series, and to assess if there are changes over time in pup condition. This is the sort of data that will enable analyses necessary to address one of the recommendations from ICES (2006): "Continue work on the relationship between hooded seal growth and condition, and environmental conditions". The sample size is chosen on the basis of previous samples sizes in the time series, and all samplings were performed by scientific personnel onboard two of the Greenland Sea sealers. A few adults were taken for other scientific purposes. (Haug and Zabavnikov, SEA 181)

As seen from Svetochev (SEA 192), some Russian data on Greenland Sea hooded seal pup weights are available from 1991 and 1992.

5.1.3 Biological parameters

Frie informed the working group that analyses of Greenland Sea hooded seal reproductive data are in progress, based on a Norwegian/Russian time series spanning the period 1958-1999.

5.2 The Northwest Atlantic Stock

5.2.1 Information on recent catches and regulatory measures

From 1998 – 2006, the TAC for hooded seals was set at 10,000 (Annex 8, Table 4). As a result of new data on the status of the population (Hammill and Stenson 2007) and the adoption of the precautionary approach under Objective Based Fisheries Management (OBFM), the quota was reduced to 8,200 for 2007-2009. The killing of bluebacks is prohibited in Canada. Catches of hooded seals (1+ only) have remained extremely low (Annex 6, Table 2). Since 2005, less than 50 hoods have been taken annually, with only 18 being reported in 2009.

Catches in Greenland were between 1,000 and 2,000 between the mid 1950s and 1972 (Annex 6, Table 3). Since then catches have ranged from 3,000 - 10,000, being in the 6,000 – 7,000 range in most years. The most recent data indicates that 3,293 were taken in all of Greenland in 2007.

Currently, the vast majority of hooded seals are caught in Greenland. With the exceptions of 1963-1982, when Canadian catches accounted for over 70% of the annual catches, Greenland accounted for over 65% of the hooded seals killed. In recent years, they have accounted for almost 100% of the catches.

5.2.2 Current research

Movements of hooded seals in the North Atlantic were reported in Anderson *et al*. (2009) and Bajzak *et al*. 2009). An analysis of hooded seal reproductive parameters will soon be published.

Canada is continuing research on diet, reproductive rates and growth and condition.

6 Advice for ACOM and NAFO

The chairman of WGHARP, with assistance from former Chairs, Haug and Stenson, will work with ACOM to prepare advice for ICES and NAFO, and circulate the advice to the WG for their final review.

7 Other business

Members of WGHARP unanimously recommended to ACOM that Dr. Mike Hammill serve as Chair for the WG for the next three meetings. They also thanked the outgoing chairs for his efforts over the past 3 years.

The next meeting is tentatively scheduled for the Russian Commonwealth (likely Murmansk) or the U.S. in August 2011. The following meeting (August 2013) will likely be held in either Canada or the US.

8 Adoption of the report

The WG adopted the report on 27 August 2009, at the close of the meeting.

Annex 1: List of participants

NAME	ADDRESS	PHONE/FAX	EMAIL
Richard Merrick (Chair)	National Marine Fisheries Services Northeast Fisheries Science Center 166 Water Street Woods Hole MA 02543-1026 United States	Phone 1 50 849 52291	richard.merrick@noaa.gov
Anne Kristine Frie	Institute of Marine Research Institute of Marine Research Tromsø P.O. Box 6404 N-9294 Tromsø Norway	Phone 47 776 09729	anne.kristine.frie@imr.no
Mike Hammill	Fisheries and Oceans Canada Institut Maurice-Lamontagne P.O. Box 1000 Mont-Joli QC G5H 3Z4 Canada	Phone 1 418 775 0580	hammillm@dfo-mpo.gc.ca
Tore Haug	Institute of Marine Research Institute of Marine Research Tromsø P.O. Box 6404 N-9294 Tromsø Norway	Phone 47 776 09722	tore.haug@imr.no
Finn Kapel	Skovvænget 10A, DK-2970 Hørsholm Denmark	Phone 45 45 865253	foka@pc.dk
Viktor Korzhev	Knipovich Polar Research Institute of Marine Fisheries and Oceanography 6 Knipovitch Street RU-183763 Murmansk Russian Federation	Phone 7 815 247 2469	korgev@pinro.ru
Kjell Tormod Nilssen	Institute of Marine Research, PO Box 6404, N-9294 Tromsø Norway	Phone 47 776 09724	kjelltn@imr.no
Tor Arne Øigård	Tor Arne Øigård Institute of Marine Research Tromsø P.O. Box 6404 N-9294 Tromsø Norway	Phone 47 776 097 30	tor.arne.oeigaard@imr.no
Ilyas Shafikov	Knipovich Polar Research Institute of Marine Fisheries and Oceanography 6 Knipovitch Street RU-183763 Murmansk Russian Federation	Phone +7	ils@pinro.ru

Garry Stenson	Fisheries and Oceans Canada Northwest Atlantic Fisheries Center P.O. Box 5667 St John s NL A1C 5X1 Canada	Phone 1 709 772 5598	Garry.Stenson@dfo-mpo.gc.ca
Vladimir Zabavnikov	Knipovich Polar Research Institute of Marine Fisheries and Oceanography 6 Knipovitch Street RU-183763 Murmansk Russian Federation	Phone 7 815 247 2572	ltei@pinro.ru

Annex 2: Agenda

Monday, 24 August

1:00pm to 1:30pm -- Introductory Comments (Merrick, Haug and Stenson)

1:30pm to 2:00pm – Discussion of Terms of References

2:00pm to 5:30pm – Harp Seals: White Sea and Barents Sea Stock

- Information on recent catches and regulatory measures (SEA181)
- Current Research (SEA182)
- Biological parameters (SEA191)
- Population assessments (SEA180, SEA187, SEA188, SEA189, SEA190)
- Catch Options (SEA189)

5:30pm Break for Day

Tuesday, 25 August

9:00 am to noon – Harp Seals: White Sea and Barents Sea Stock

- Continue Monday discussions
- Review results of intersessional WG

Noon to 1:00pm – Lunch

1:00pm to 5:30pm - Harp Seals: Greenland Sea Stock

- Information on recent catches and regulatory measures (SEA181)
- Current Research (SEA186)
- Biological parameters (SEA185)
- Population assessments (SEA183)
- Catch Options (SEA183)

5:30pm Break for Day

Wednesday, 26 August

9:00am to 11:00am -- Harp Seals: Northwest Atlantic Stock

- Information on recent catches and regulatory measures (SEA184, SEA193)
- Current Research
- Biological parameters
- Population assessments

11:00am to 11:30am -- Hooded Seals: Greenland Sea Stock

- Information on recent catches and regulatory measures (SEA181)
- Current Research
- Biological parameters (SEA192)

10:00am to 10:30 am —Hooded Seals: Northwest Atlantic Stock

- Information on recent catches and regulatory measures (SEA184, SEA193)
- Current Research

10:30 am to noon – Other Business

- Research Recommendations
- TOR for next meeting
- Identify new chair
- Other business

Noon to 1:00pm – Lunch

1:00pm to 5:30pm

- Report writing

5:30pm Break for Day

Thursday, 27 August

9:00am to noon

- Finish report writing

Noon to 1:00pm – Lunch

1:00pm to 5:30pm –

- What next for Barents Sea/White Sea harp assessment

5:30pm – Conclude meeting

Annex 3: WGHARP terms of reference for the next meeting

The **Working Group on Harp and Hooded Seals (WGHARP)** (Chair: TBD) will meet in the Russian Commonwealth or U.S. for 4-5 days during August 2011 to:

Review results of 2010-2011 surveys

Provide quota advice to ICES/NAFO member states of their harvests of harp and hooded seals;

Provide advice on other issues as requested

The following meeting is proposed to be held in North America (either Canada or the US).

WGHARP will report September 2011 for the attention of the ACOM.

Supporting Information

PRIORITY:	High priority as a tool for the assessment and management of harp and hooded seal in the North Atlantic Ocean. WGHARP receives requests for advice from member countries through ACOM and/or NAFO Scientific Council, incuding recognition of the need for a precautionary approach to mangement of seal populations.
SCIENTIFIC JUSTIFICATION AND RELATION TO ACTION PLAN:	Action Numbers 4.3 and 4.3 A number of North Atlantic nations currently harvest harp and hooded seal stocks, and there is a need for a relatively neutral forum for developing and vetting scientific advice on sustainable harvests of these stocks. The WGHARP provides this forum through the inclusion of ICES and NAFO member state scientists expert in pinniped biology and the quantiative techniques necessary for development of sound catch advice; members represent all harvesting nations as well as nations without seal harvests. The activities of WGHARP are particularly relevant to action plan goals 3 and 4
RESOURCE REQUIREMENTS:	None beyond the contributions from member states
PARTICIPANTS:	The Group is normally attended by some 10-15 members and guests.
SECRETARIAT FACILITIES:	None
FINANCIAL:	None
LINKAGES TO ADVISORY COMMITTEES:	WGHARP reports to ACOM and NAFO Sc.C.
LINKAGES TO OTHER COMMITTEES OR GROUPS:	LRC, RMC, WGMME, WGNPBW.
LINKAGES TO OTHER ORGANIZATIONS:	NOAA/NMFS, NAMMCO, Joint Norwegian-Russian Fisheries Committee. The work of this group is closely aligned with harp and hooded seal research and management programs conducted by the governments of Canada, Greenland, Norway, Russia, and the United States

Annex 4: Recommendations

Recommendation	Action By
1. Modify Northeast Model to allow it to account for changes in reproductive rates	**Norway and Russia**
2. Explore effects of mid-1980s and 1995 mortality Events in White Sea and its potential contribution to the current decline in pup production	**Norway and Russia**
3. Collect additional Movement/distribution data (e.g., using satellite tagging) on White Sea/Barents Sea harp seals	**Greenland, Norway and Russia**
4. Collect additional Age Structure, Condition and reproductive data on all harp and hooded seal stocks	**Canada, Greenland, Norway, and Russia**
5. Conduct surveys to determine if significant harp and hooded seal whelping occurs outside of traditional areas	**Russia, Greenland, Norway**
6. In future surveys of White Sea, place markers (e.g., drifters) on ice to track movement of whelping patches	**Russia**
7. Support additional research on sea ice-seal whelping relationships	**Norway, Russia, Canada, and Greenland**
8. Continue harp seal genetic analyses with larger sample size	**Greenland, Norway, Russia, and Canada**
9. Continue evaluation of readers and reading techniques	**Canada, Norway, and Russia**
10. Peer review Shafikov abundance estimation methods	**Russia**

Annex 5: References

Number	Author	Title
SEA180	T. A. Øigård, V. B. Zabavnikov, I. Shafikov, and T.Haug,	Comparison of methods for analysing aerial photos in SEAL pup production estimation applied by PINRO and IMR
SEA181	T. Haug and V. Zabavnikov	Norwegian and Russian catches of harp and hooded seals in the northeast Atlantic in 2009
SEA182	T. A. Øigård, T. Haug, U. Lindstrøm and K. T. Nilssen	Year-to-year variations in body condition of Barents Sea harp seals during April-may in 1992-2006
SEA183	T. A. Øigård, T. Haug, and K. T. Nilssen	The 2009 abundance of harp seals (*pagophilus groenlandicus*) in the greenland sea
SEA184	A. Rosvid	Greenland Sea Harp and Hooded Seal Catchs through 2007
SEA185	A. K. Frie	An update on reproductive parameters of Greenland Sea harp seals (*Pagophilus groenlandicus*)
SEA186	A. K. Frie	Validation of image based age determinations of known-age harp seals, *Pagophilus groenlandicus*: Results from a trans-Atlantic blind reading experiment
SEA187	V. B. Zabavnikov, I.N. Shafikov	Results Of The White/Barents Seas Harp Seal Population (*Phoca Groenlandica*) Aerial Accounted Research In Whelping Patches Carried Out By Pinro In 2009, Assessment Of Current Status With Pup Production And Possible Perspectives
SEA188	I.N. Shafikov	Probabilistic approach for defenition of the white/barents seas harp seal (*phoca groenlandica*) population pup production numbers on aerial surveys data
SEA189	V. Korzhev	Abundance estimation of the white sea harp seal population (*phoca groenlandica*) and harvesting strategy in 2010-2012
SEA190	I.N. Shafikov	The white/barents seas harp seal (*phoca groenlandica*) population maximum express assessement on data of breeding accounting
SEA191	N. Øien and Hartvedt	Age distributions in harp seal catches during moult in the southeastern Barents Sea after 1993
SEA192	V. Svetochev	Data Of The Hooded Seal Breeding In The Greenland Sea In 1991 And 1992
SEA193	G. Stenson	Harp and hooded seals in canada: total and allowable catches, 2006 – 2009

Other References

Author	Year	Citation
J. M. Andersen, J.M., Y. F. Wiersma, G. Stenson, M. O. Hammill and A. Rosing-	2009	Movement Patterns of Hooded Seals (Cystophora cristata) in the Northwest Atlantic Ocean during the Post-Moult and Pre-Breed Seasons. J. Northw. Atl. Fish. Sci., Vol. 42: 1–11.

Asvid		
C. E. Bajzak, S. D. Côté, M. O. Hammill and G. Stenson	2009	Intersexual differences in the postbreeding foraging behaviour of the northwest Atlantic hooded seal. Mar. Ecol. Prog. Ser.385:285-294.
D. Chabot and G. B. Stenson	2002	Growth and seasonal fluctuations in size and condition of male Northwest Atlantic harp seals (*Phoca groenlandica*): An analysis using sequential growth curves. Mar. Ecol. Prog. Ser. 227:25-42.
N. Øien, N. and T. Øritsland	1995	Use of mark-recapture experiments to monitor seal populations subject to catching. In: Whales, Seals, Fish and Man. Elsivier Science B. V., Amsterdam, pp. 35-45.
T.A. Øigård, T. Haug, K.T. Nilssen, and A. –B. Salberg	2009	Estimation of pup production of hooded and harp seals in the Greenland Sea in 2007: Reducing uncertainty using Generalized Additive Models. J. Northw. Atl. Fish. Sci. 42: in press.
G. Stenson	2008	Recent catches of harp seals (*Pagophilus groenlandicus*) in the Northwest Atlantic. DFO Can. Sci. Advis. Sec Res. Doc 2008/080.
WGHARP	2006a	Report of the Joint ICES/NAFO Working Group on Harp and Hooded Seals, 30 August – 3 September, 2005, St. John's, Newfoundland, Canada. ICES CM 2006/ACFM. 44 Pp.
WGHARP	2006b	Report of the Working Group on ICES/NAFO Working Group on Harp and Hooded Seals (WGHARP), 12-16 June 2006, ICES Headquarters. ICES CM 2006/ACFM:32. 28 pp.
WGHARP	2008	Report of the Working Group on ICES/NAFO Working Group on Harp and Hooded Seals (WGHARP), 27-30 August, Tromso, Norway. ICES CM 2008/ACOM:17. 57 pp.

Annex 6: Catches of hooded seals including catches taken according to scientific permits

Table 1. Catches of hooded seals in the Greenland Sea ("West Ice") from 1946 through 2009[a]. Totals include catches for scientific purposes.

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

Year	Norwegian catches			Russian catches			Total catches		
	Pups	1 year and older	Total	Pups	1 year and older	total	Pups	1 year and older	Total
1996	575	236	811	-	-	-	575	236	811
1997	2765	169	2934	-	-	-	2765	169	2934
1998	5597	754	6351	-	-	-	5597	754	6351
1999	3525	921	4446	-	-	-	3525	921	4446
2000	1346	590	1936	-	-	-	1346	590	1936
2001	3129	691	3820	-	-	-	3129	691	3820
2002	6456	735	7191	-	-	-	6456	735	7191
2003	5206	89	5295	-	-	-	5206	89	5295
2004	4217	664	4881	-	-	-	4217	664	4881
2005	3633	193	3826	-	-	-	3633	193	3826
2006	3079	568	3647				3079	568	3647
2007	27	35	62				27	35	62
2008	9	35	44				9	35	44
2009	396	17	413	-	-	-	396	17	413

[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. These catches are not included.

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

Table 2. Canadian catches of hooded seals off Newfoundland and in the Gulf of St. Lawrence, Canada ("Gulf" and "Front"), 1946-2009[a,b]. Catches from 1995 onward includes catches under personal use licences. YOY refers to Young of Year. Catches from 1990-1996 were not assigned to age classes. With the exception of 1996, all were assumed to be 1+.

	Large Vessel Catches				Landsmen Catches[c]				Total Catches			
Year	YOY	1+	Unk	Total	YOY	1+	Unk	Total	YOY	1+	Unk	Total
1946-50	4029	2221	0	6249	429	184	0	613	4458	2405	0	6863
1951-55	3948	1373	0	5321	494	157	0	651	4442	1530	0	5972
1956-60	3641	2634	0	6275	106	70	0	176	3747	2704	0	6451
1961-65	2567	1756	0	4323	521	199	0	720	3088	1955	0	5043
1966-70	7483	5220	0	12703	613	211	24	848	8096	5431	24	13551
1971	7987	6875	0	14862	54	30	0	84	8041	6905	0	14946
1972	6820	5636	0	12456	108	36	0	144	6928	5672	0	12600
1973	4499	1930	0	6429	103	35	0	138	4602	1965	0	6567
1974	5984	3990	0	9974	7	18	0	25	5991	4008	0	9999
1975	7459	7805	0	15264	187	160	0	347	7646	7965	0	15611
1976	6065	5718	0	11783	475	127	0	602	6540	5845	0	12385
1977	7967	2922	0	10889	1003	201	0	1204	8970	3123	0	12093
1978	7730	2029	0	9759	236	509	0	745	7966	2538	0	10504
1979	11817	2876	0	14693	131	301	0	432	11948	3177	0	15125
1980	9712	1547	0	11259	1441	416	0	1857	11153	1963	0	13116
1981	7372	1897	0	9269	3289	1118	0	4407	10661	3015	0	13676
1982	4899	1987	0	6886	2858	649	0	3507	7757	2636	0	10393
1983	0	0	0	0	0	128	0	128	0	128	0	128
1984	206	187	0	393[d]	0	56	0	56	206	243	0	449
1985	215	220	0	435[d]	5	344	0	349	220	564	0	784
1986	0	0	0	0	21	12	0	33	21	12	0	33
1987	124	4	250	378	1197	280	0	1477	1321	284	250	1855
1988	0	0	0	0	828	80	0	908	828	80	0	908
1989	0	0	0	0	102	260	5	367	102	260	5	367
1990	41	53	0	94[d]	0	0	636[e]	636	41	53	636	730
1991	0	14	0	14[d]	0	0	6411[e]	6411	0	14	6411	6425
1992	35	60	0	95[d]	0	0	119[e]	119	35	60	119	214
1993	0	19	0	19[d]	0	0	19[e]	19	0	19	19	38
1994	19	53	0	72[d]	0	0	149[e]	149	19	53	149	221
1995	0	0	0	0	0	0	857[e]	857	0	0	857[e]	857
1996	0	0	0	0	0	0	25754[e]	25754	0	22,847[f]	2907	25754
1997	0	0	0	0	0	7058	0	7058	0	7058[e]	0	7058
1998	0	0	0	0	0	10148	0	10148	0	10148[e]	0	10148
1999 [e]	0	0	0	0	0	201	0	201	0	201[e]		201
2000 [e]	2	2	0	4[d]	0	10	0	10	2	12[e]	0	14
2001[e]	0	0	0	0	0	140	0	140	0	140[e]	0	140
2002 [e]	0	0	0	0	0	150	0	150	0	150[e]	0	150
2003 [e]	0	0	0	0	0	151	0	151	0	151[e]	0	151
2004 [e]	0	0	0	0	0	389	0	389	0	389[e]	0	389
2005 [e]	0	0	0	0	0	20	0	20	0	20[e]	0	20

2006[e]	0	0	0	0	0	40	0	40	0	40	0	40
2007[e]	0	0	0	0	0	17	0	17	0	17	0	17
2008[e]	0	0	0	0	0	5	0	5	0	5	0	5
2009[e]	0	0	0	0	0	18	0	18	0	18	0	18

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

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

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

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

[e] Statistics no longer split by age; commercial catches of bluebacks are not allowed

[f] Number of YOY estimated from reported illegal catches

Table 3. Catches of hooded seals in West and East Greenland 1954–2007.

Year	West Atlantic Population				NE	All Greenland
	West	KGH[b]	Southeast	Total		
1954	1097	-	201	1298	-	1298
1955	972	-	343	1315	1	1316
1956	593	-	261	854	3	857
1957	797	-	410	1207	2	1209
1958	846	-	361	1207	4	1211
1959	780	414	312	1506	8	1514
1960	965	-	327	1292	4	1296
1961	673	803	346	1822	2	1824
1962	545	988	324	1857	2	1859
1963	892	813	314	2019	2	2021
1964	2185	366	550	3101	2	3103
1965	1822	-	308	2130	2	2132
1966	1821	748	304	2873	-	2873
1967	1608	371	357	2336	1	2337
1968	1392	20	640	2052	1	2053
1969	1822	-	410	2232	1	2233
1970	1412	-	704	2116	9	2125
1971	1634	-	744	2378	-	2378
1972	2383	-	1825	4208	2	4210
1973	2654	-	673	3327	4	3331
1974	2801	-	1205	4006	13	4019
1975	3679	-	1027	4706	58a	4764
1976	4230	-	811	5041	22a	5063
1977	3751	-	2226	5977	32a	6009
1978	3635	-	2752	6387	17	6404
1979	3612	-	2289	5901	15	5916
1980	3779	-	2616	6395	21	6416
1981	3745	-	2424	6169	28a	6197
1982	4398	-	2035	6433	16a	6449
1983	4155	-	1321	5476	9a	5485
1984	3364	-	1328	4692	17	4709
1985	3188	-	3689	6877	6	6883
1986	2796a	-	3050a	5846a	-a	5846a
1987	2333a	-	2472a	4805a	3a	4808a
1988–92c						
1993	4983	-	1967	6950	32	6982
1994	5060	-	3048	8108	34	8142
1995	4429		2702	7131	48	7179
1996	6066	-	3801	9867	24	9891
1997	5250		2175	7425	67	7492
1998	5051		1270	6321	14	6335
1999	4852	-	2587	7439	16	7455
2000	3769	-	2046	5815	29	5844

Year	West Atlantic Population				NE	All Greenland
	West	KGH[b]	Southeast	Total		
2001	5010	-	1496	6506	8	6514
2002	3606	-	1189	4795	11	4806
2003	4351	-	1992	6343	10	6353
2004	4133		1690	5823	20	5843
2005	3092		1022	4114	14	4128
2006	4194		550	4744	3	4747
2007	2574	-	712	3286	7	3293

[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.

Annex 7: Catches of harp seals including catches taken according to scientific permits

Table 1. Catches of harp seals in the Greenland Sea ("West Ice") from 1946 through 2009[a]. Totals include catches for scientific purposes.

Year	Norwegian catches			Russian catches			Total catches		
	Pups	1 year and older	Total	pups	1 year and older	Total	Pups	1 year and older	Total
1946–50	26606	9464	36070	-	-	-	26606	9464	36070
1951–55	30465	9125	39590	-	-	-b	30465	9125	39590
1956–60	18887	6171	25058	1148	1217	2365b	20035	7388	27423
1961–65	15477	3143	18620	2752	1898	4650	18229	5041	23270
1966–70	16817	1641	18458	1	47	48	16818	1688	18506
1971	11149	0	11149	-	-	-	11149	0	11149
1972	15100	82	15182	-	-	-	15100	82	15182
1973	11858	0	11858	-	-	-	11858	0	11858
1974	14628	74	14702	-	-	-	14628	74	14702
1975	3742	1080	4822	239	0	239	3981	1080	5061
1976	7019	5249	12268	253	34	287	7272	5283	12555
1977	13305	1541	14846	2000	252	2252	15305	1793	17098
1978	14424	57	14481	2000	0	2000	16424	57	16481
1979	11947	889	12836	2424	0	2424	14371	889	15260
1980	2336	7647	9983	3000	539	3539	5336	8186	13522
1981	8932	2850	11782	3693	0	3693	12625	2850	15475
1982	6602	3090	9692	1961	243	2204	8563	3333	11896
1983	742	2576	3318	4263	0	4263	5005	2576	7581
1984	199	1779	1978	-	-	-	199	1779	1978
1985	532	25	557	3	6	9	535	31	566
1986	15	6	21	4490	250	4740	4505	256	4761
1987	7961	3483	11444	-	3300	3300	7961	6783	14744
1988	4493	5170	9663c	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

Year	Norwegian catches			Russian catches			Total catches		
	Pups	1 year and older	Total	pups	1 year and older	Total	Pups	1 year and older	Total
1996	5649	778	6427	-	-	-	5649	778	6427
1997	1962	199	2161	-	-	-	1962	199	2161
1998	1707	177	1884	-	-	-	1707	177	1884
1999	608	195	803	-	-	-	608	195	803
2000	6328	6015	12343	-	-	-	6328	6015	12343
2001	2267	725	2992	-	-	-	2267	725	2992
2002	1118	114	1232	-	-	-	1118	114	1232
2003	161	2116	2277				161	2116	2277
2004	8288	1607	9895				8288	1607	9895
2005	4680	2525	7205				4680	2525	7205
2006	2343	961	3304				2343	961	3304
2007	6188	1640	7828				6188	1640	7828
2008	744	519	1263				744	519	1263
2009	5177	2918	8035	-	-	-	5117	2918	8035

[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.

Table 2. Catches of harp seals in the White and Barents Seas ("East Ice"), 1946–2009[a,b].

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

Year	Norwegian catches			Russian catches			Total catches		
	Pups	1 year and Older	Total	Pups	1 year and Older	Total	Pups	1 year and Older	Total
1997	15	5004	5019	31319	61	31380	31334	5065	36399
1998	18	814	832	13350	20	13370	13368	834	14202
1999	173	977	1150	34850	0	34850	35023	977	36000
2000	2253	4104	6357	38302	111	38413	40555	4215	44770
2001	330	4870	5200	39111	5	39116	39441	4875	44316
2002	411	1937	2348	34187	0	34187	34598	1937	36535
2003	2343	2955	5298	37936	0	37936	40279	2955	43234
2004	0	33	33	0	0	0	0	33	33
2005	1162	7035	8197	14258	19	14277	15488	9405	22474
2006	147	9939	10086	7005	102	7107	7152	10041	17193
2007	242	5911	6153	5276	200	5476	5518	6111	11629
2008	0	0	0	13331	0	13331	13331	0	13331
2009	0	0	0	0	0	0	0	0	0

[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 14o E, by one ship which mainly operated in the Greenland Sea.

Table 3. Reported catches of harp seals in the northwest Atlantic for 1952-2009. Estimated catches are indicated by shading.

Year	Front & Gulf	Canadian Arctic	Greenland	NW Atlantic Total
1952	307,108	1,784	16,400	325,292
1953	272,886	1,784	16,400	291,070
1954	264,416	1,784	19,150	285,350
1955	333,369	1,784	15,534	350,687
1956	389,410	1,784	10,973	402,167
1957	245,480	1,784	12,884	260,148
1958	297,786	1,784	16,885	316,455
1959	320,134	1,784	8,928	330,846
1960	277,350	1,784	16,154	295,288
1961	187,866	1,784	11,996	201,646
1962	319,989	1,784	8,500	330,273
1963	342,042	1,784	10,111	353,937
1964	341,663	1,784	9,203	352,650
1965	234,253	1,784	9,289	245,326
1966	323,139	1,784	7,057	331,980
1967	334,356	1,784	4,242	340,382
1968	192,696	1,784	7,116	201,596
1969	288,812	1,784	6,438	297,034
1970	257,495	1,784	6,269	265,548
1971	230,966	1,784	5,572	238,322
1972	129,883	1,784	5,994	137,661
1973	123,832	1,784	9,212	134,828
1974	147,635	1,784	7,145	156,564
1975	174,363	1,784	6,752	182,899
1976	165,002	1,784	11,956	178,742
1977	155,143	1,784	12,866	169,793
1978	161,723	2,129	16,638	180,490
1979	160,541	3,620	17,545	181,706
1980	169,526	6,350	15,255	191,131
1981	202,169	4,672	22,974	229,815
1982	166,739	4,881	26,927	198,547
1983	57,889	4,881	24,785	87,555
1984	31,544	4,881	25,829	62,254
1985	19,035	4,881	20,785	44,701
1986	25,934	4,881	26,099	56,914
1987	46,796	4,881	37,859	89,536
1988	94,046	4,881	40,415	139,342
1989	65,304	4,881	42,971	113,156
1990	60,162	4,881	45,526	110,569
1991	52,588	4,881	48,082	105,551
1992	68,668	4,881	50,638	124,187
1993	27,003	4,881	56,319	88,203
1994	61,379	4,881	59,684	125,944
1995	65,767	4,881	66,298	136,946
1996	242,906	4,881	73,947	321,734
1997	264,210	2,500[a]	68,816	335,526
1998	282,624	1,000[a]	81,272	364,896
1999	244,552	500[a]	93,117	338,169
2000	92,055	400[a]	98,459	190,914
2001	226,493	600[a]	85,428	312,521

Year	Front & Gulf	Canadian Arctic	Greenland	NW Atlantic Total
2002	312,367	1,000	66,735	380,102
2003	289,512	1,000	66,149	356,661
2004	365,971	1,000	70,586	437,557
2005	323,826	1,000	91,696	416,522
2006	354,867	1,000	92,210	448,077
2007	224,745	1,000	82,778	308,523
2008	217,850	1,000	80,648[b]	299,498
2009	72,407	1,000	80,648[b]	154,055

[a] Rounded
[b] Average of catches 2003-2007

Table 4. Harp seal catches off Newfoundland and in the Gulf of St. Lawrence, Canada ("Gulf" and "Front"), 1946–2009[a,b]. Catches from 1995 onward include catches under the personal use licences.

Year	Large Vessel Catch				Landsmen Catch				Total Catches			
	Pups	1+	Unk	Total	Pups	1+	Unk	Total	Pups	1+	Unk	Total
1946-50	108256	53763	0	162019	44724	11232	0	55956	152980	64995	0	217975
1951-55	184857	87576	0	272433	43542	10697	0	54239	228399	98273	0	326672
1956-50	175351	89617	0	264968	33227	7848	0	41075	208578	97466	0	306044
1961-65	171643	52776	0	224419	47450	13293	0	60743	219093	66069	0	285162
1966-70	194819	40444	0	235263	32524	11633	0	44157	227343	52077	0	279420
1971	169426	14343	0	183769	41153	6044	0	47197	210579	20387	0	230966
1972	104109	1646	0	105755	12701	11427	0	24128	116810	13073	0	129883
1973	63369	15081	0	78450	34966	10416	0	45382	98335	25497	0	123832
1974	85387	21828	0	107215	29438	10982	0	40420	114825	32810	0	147635
1975	109832	10992	0	120824	30806	22733	0	53539	140638	33725	0	174363
1976	93939	4576	0	98515	38146	28341	0	66487	132085	32917	0	165002
1977	92904	2048	0	94952	34078	26113	0	60191	126982	28161	0	155143
1978	63669	3523	0	67192	52521	42010	0	94531	116190	45533	0	161723
1979	96926	449	0	97375	35532	27634	0	63166	132458	28083	0	160541
1980	91577	1563	0	93140	40844	35542	0	76386	132421	37105	0	169526
1981[d]	89049	1211	0	90260	89345	22564	0	111909	178394	23775	0	202169
1982	100568	1655	0	102223	44706	19810	0	64516	145274	21465	0	166739
1983	9529	1021	0	10550	40529	6810	0	47339	50058	7831	0	57889
1984	95	549	0	644[e]	23827	7073	0	30900	23922	7622	0	31544
1985	0	1	0	1[e]	13334	5700	0	19034	13334	5701	0	19035
1986	0	0	0	0	21888	4046	0	25934	21888	4046	0	25934
1987	2671	90	0	2761	33657	10356	22	44035	36350	10446	0	46796
1988	0	0	0	0	66972	13493	13581	94046	66972	27074	0	94046
1989	1	231	0	232[e]	56345	5691	3036	65072	56346	8958	0	65304
1990	48	74	0	122[e]	34354	23725	1961	60040	34402	25760	0	60162
1991	3	20	0	23[e]	42379	5746	4440	52565	42382	10206	0	52588
1992	99	846	0	945[e]	43767	21520	2436	67723	43866	24802	0	68668
1993	8	111	0	119[e]	16393	9714	777	26884	16401	10602	0	27003
1994	43	152	0	195[e]	25180	34939	1065	61184	25223	36156	0	61379
1995	21	355	0	376[e]	33615	31306	470	65391	34106	31661	0	65767
1996	3	186	0	189[e]	184853	57864	0	242717	184856	58050	0	242906
1997	0	6	0	6[e]	220476	43728	0	264204	220476	43734	0	264210
1998	7	547	0	554[e]	0	0	282070	282070	7	547	282070	282624
1999	26	25	0	51[e]	221001	6769	16782	244552	221027	6794	16782	244603
2000	16	450	0	466[e]	85035	6567	0	91602	85485	6583	0	92068
2001	0	0	0	0	214754	11739	0	226493	214754	11739	0	226493
2002	0	0	0	0	297764	14603	0	312367	297764	14603	0	312367
2003	0	0	0	0	280174	9338	0	289512	280174	9338	0	289512
2004	0	0	0	0	353553	12418	0	365971	353553	12418	0	365971
2005[f]	0	0	0	0	319127	4699	0	323820	319127	4699	0	323820
2006	0	0	0	0	346426	8441	0	354867	346426	811	0	354867
2007	0	0	0	0	221488	3257	0	224745	221488	3257	0	224745
2008	0	0	0	0	217565	285	0	217850	217565	285	0	217850
2009	0	0	0	0	72407	0	0	72407	72407	0	0	72407

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

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

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

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

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

Table 5. Catches of harp seals in Greenland, 1954–1987 (List-of-Game), and 1993–2007 (Piniarneq), and % adults[a] according to the hunters' reports.

Year	West Greenland		South East Greenland		North East Greenland		All
	Catch num-	%	Catch num-	%	Catch num-	%	Catch num-
1954	18,912		475		32		19,419
1955	15,445		178		45		15,668
1956	10,883		180		5		11,068
1957	12,817		133		40		12,990
1958	16,705		360		30		17,095
1959	8,844		168		7		9,019
1960	15,979		350		16		16,345
1961	11,886		219		13		12,118
1962	8,394		211		10		8,615
1963	10,003	21	215	28	20	50	10,238
1964	9,140	26	125	40	7	86	9,272
1965	9,251	25	76	65	2	100	9,329
1966	7,029	29	55	55	6		7,090
1967	4,215	38	54	35	10		4,279
1968	7,026	30	180	47	4		7,210
1969	6,383	21	110	62	9		6,502
1970	6,178	26	182	70	15	100	6,375
1971	5,540	24	63	48	5		5,608
1972	5,952	16	84	48	6	100	6,042
1973	9,162	19	100	20	38	79	9,300
1974	7,073	21	144	29	27	95	7,244
1975	5,953	13	125	20	68	72	6,146
1976	7,787	12	260	48	27	55	8,074
1977	9,938	15	72	16	21	81	10,031
1978	10,540	16	408	14	30	36	10,978
1979	12,774	20	171	19	18	25	12,963
1980	12,270	17	308	14	45		12,623
1981	13,605	21	427	15	49		14,081
1982	17,244	16	267	20	50	60	17,561
1983	18,739	19	357	56	57	30	19,153
1984	17,667	16	525	19	61		18,253
1985	18,445	2	534	0	56	52	19,035
1986	13,932[b]	10	533[b]	18	37[b]	65	14,502[b]
1987	16,053[b]	21	1060[b]	24	15[b]	60	17,128[b]
1988-	For 1988 to 1992 comparable catch statistics are not available.						
1993	55,792	50	1,054	30	40	93	56,886
1994	56,941	50	864	30	88	65	57,893
1995	62,296	53	906	36	61	52	63,263
1996	73,287	52	1,320	35	69	59	74,676
1997	68,241	49	1,149	28	201	58	69,591
1998	80,437	51	1,670	30	110	73	82,217
1999	91,321	50	3,592	12	104	65	95,017
2000	97,229	44	2,459	15	113	76	99,801
2001	84,165	42	2,525	18	73	68	86,763
2002	65,810	46	1,849	19	66	86	67,725
2003	64,735	44	2,828	24	44	77	67,607
2004	69,273	41	2,625	27	207	29	72,105
2005	90,308	35	2,775	18	38	58	93,121
2006	91,191	33	2,038	16	89	78	93,318
2007	81,427	32	2,702	21	85	53	84,214

[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 6. Estimated catches of harp seals in Greenland, 1975–1987 and 1993–1995. Figures in bold are non-corrected figures from Table 5.

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

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

Table 7. Estimated total removals of harp seals in the northwest Atlantic for 1952-2009.

Year	Reported	Bycatch	Struck and Lost	Total
1952	325,292	0	129,230	454,522
1953	291,070	0	95,095	386,165
1954	285,350	0	112,084	397,434
1955	350,687	0	100,938	451,625
1956	402,167	0	64,218	466,385
1957	260,148	0	96,381	356,529
1958	316,455	0	176,883	493,338
1959	330,846	0	94,426	425,272
1960	295,288	0	140,697	435,985
1961	201,646	0	34,532	236,178
1962	330,273	0	125,277	455,550
1963	353,937	0	86,250	440,187
1964	352,650	0	88,959	441,609
1965	245,326	0	64,414	309,740
1966	331,980	0	83,382	415,362
1967	340,382	0	65,438	405,820
1968	201,596	0	46,718	248,314
1969	297,034	0	66,051	363,085
1970	265,548	68	50,313	315,929
1971	238,322	490	29,870	268,682
1972	137,661	621	22,031	160,313
1973	134,828	465	37,486	172,779
1974	156,564	182	42,899	199,645
1975	182,899	285	43,681	226,865
1976	178,742	1092	47,991	227,825
1977	169,793	1577	44,094	215,464
1978	180,490	2919	65,474	248,883
1979	181,706	3310	50,585	235,601
1980	191,131	2717	60,048	253,896
1981	229,815	3921	53,222	286,958
1982	198,547	3785	54,740	257,071
1983	87,555	4962	40,131	132,648
1984	62,254	4108	39,591	105,952
1985	44,701	4857	32,069	81,627
1986	56,914	8178	36,178	101,269
1987	89,536	13096	55,099	157,731
1988	139,342	8545	75,895	223,781
1989	113,156	10256	59,775	183,187
1990	110,569	3621	77,978	192,168
1991	105,551	9689	65,400	180,640
1992	124,187	25476	82,629	232,292
1993	88,203	26472	72,665	187,340
1994	125,944	47255	102,049	275,248
1995	136,946	20395	104,635	261,975
1996	321,734	29201	146,607	497,542
1997	335,526	18869	126,654	481,048
1998	364,896	4641	126,725	496,262
1999	338,169	16111	113,033	467,313
2000	190,914	11347	110,354	312,615
2001	312,521	19475	109,069	441,065
2002	380,102	9329	98,009	487,440

Year	Reported	Bycatch	Struck and Lost	Total
2003	356,661	5367	91,233	453,261
2004	437,557	12330.4[a]	102,612	552,498
2005	416,522	12330.4[a]	114,191	543,043
2006	448,077	12330.4[a]	119,884	580,291
2007	308,523	12330.4[a]	98,692	407215
2008	299,498	12330.4[a]	93,384	392,882
2009	154,055	12330.4[a]	85,459	239,514

[a]**Average bycatch 1999-2003 in Canadian and US fisheries**

Annex 8: Summary of harp and hooded sealing regulations

Table 1. Summaries of Norwegian harp and hooded sealing regulations for the Greenland Sea ("West Ice"), 1985–2009.

Year	Opening Date	Closing Date	Quotas				Allocations	
			Total	Pups	Female	Male	Norway	Soviet & Russian
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	0[3]	Incl.	23,100	6,900
1990	26 March	30 June	27,500	0	0	Incl.	19,500	8,000
1991	26 March	30 June	9,000	0	0	Incl.	1,000	8,000
1992-94	26 March	30 June	9,000	0	0	Incl.	1,700	7,300
1995	26 March	10 July	9,000	0	0	Incl.	1,700[7]	7,300
1996	22 March	10 July	9,000[8]				1,700	7,300
1997	26 March	10 July	9,000[9]				6,200	2,800[11]
1998	22 March	10 July	5,000[10]				2,200	2,800[11]
1999-00	22 March	10 July	11,200[12]				8,400	2,800[11]
2001-03	22 March	10 July	10,300[12]				10,300	
2004-05	22 March	10 July	5,600[12]				5,600	
2006	22 March	10 July	4,000				4,000	
2007-08[14]			0	0	0	0	0	0
2009			0	0	0	0	0	0
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 Ma[8]	13,100[9]				10,600	2,500[11]
1997-98	10 April	31 May	13,100[10]				10,600	2,500[11]
1999-00	10 April	31 May	17,500[13]				15,000	2,500[11]
2001-05	10 April	31 May	15,000[13]				15,000	0
2006-07	10 April	31 May	31,200[13]				31,200	0
2008	5 April	31 May	31,200[13]				31,200	0
2009	10 April	31 May	40,000				40,000	0

[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.

[14] Hooded seals protected, only small takes for scientific purposes allowed.

Table 2. Summary of sealing regulations for the White and Barents Seas ("East Ice"), 1979–2009.[1]

Year	Opening Dates		Closing Date	Quota-Allocation		
	Soviet/Rus.	Norway		Total	Soviet/Rus.	Norway
1979–80	1 March	23 March	30 April3	50,0004	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 April3	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	8,7505
1996	-	-	-	40,000	30,500	9,500
1997-98	-	-	-	40,000	35,000	5,000
1999	-	-	-	21,400[6]	16,400	5,000
2000	27 Febr	-	-	27,700[6]	22,700	5,000
2001-02	-	-	-	53,000[6]	48,000	5,000
2003	-	-	-	53,000[6]	43,000	10,000
2004-05				45,100[6]	35,100	10,000
2006	-	-	-	78,200[6]	68,200	10,000
2007	-	-	-	78,200[6]	63,200	15,000
2008	-	-	-	55,100[6]	45,100	10,000
2009	-	-	-	35,000	28,000[7]	7,000

[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 quota could be taken as pups, where 2,5 pups equalled one 1+ animal

[7] Quota initially set at 28,000 animals, but then was reconsidered and set to 0

Table 3. Major management measures implemented for harp seals in Canadian waters, 1961–2009.

Year	Management Measure
1961	Opening and closing dates set for the Gulf of the St. Lawrence and Front areas.
1964	First licensing of sealing vessels and aircraft. Quota of 50,000 set for southern Gulf (effective 1965).
1965	Prohibition on killing adult seals in breeding or nursery areas. Introduction of licensing of sealers. Introduction of regulations defining killing methods.
1966	Amendments to licensing. Gulf quota areas extended. Rigid definition of killing methods.
1971	TAC for large vessels set at 200,000 and an allowance of 45,000 for landsmen.
1972 – 1975	TAC reduced to 150,000, including 120,000 for large vessel and 30,000 (unregulated) for landsmen. Large vessel hunt in the Gulf prohibited.
1976	TAC was reduced to 127,000.
1977	TAC increased to 170,000 for Canadian waters, including an allowance of 10,000 for northern native peoples and a quota of 63,000 for landsmen (includes various suballocations throughout the Gulf of St. Lawrence and northeastern Newfoundland). Adults limited to 5% of total large vessel catch.
1978–1979	TAC held at 170,000 for Canadian waters. An additional allowance of 10,000 for the northern native peoples (mainly Greenland).
1980	TAC remained at 170,000 for Canadian waters including an allowance of 1,800 for the Canadian Arctic. Greenland was allocated additional 10,000.
1981	TAC remained at 170,000 for Canadian waters including 1,800 for the Canadian Arctic. An additional allowance of 13,000 for Greenland.
1982–1987	TAC increased to 186,000 for Canadian waters including increased allowance to northern native people of 11,000. Greenland catch anticipated at 13,000.
1987	Change in Seal Management Policy to prohibit the commercial hunting of whitecoats and hunting from large (>65 ft) vessels (effective 1988). Changes implemented by a condition of licence.
1992	First Seal Management Plan implemented.
1993	Seal Protection Regulations updated and incorporated in the Marine Mammal Regulations. The commercial sale of whitecoats prohibited under the Regulations. Netting of seals south of 54°N prohibited. Other changes to define killing methods, control interference with the hunt and remove old restrictions.
1995	Personal sealing licences allowed. TAC remained at 186,000 including personal catches. Quota divided among Gulf, Front and unallocated reserve.
1996	TAC increased to 250,000 including allocations of 2,000 for personal use and 2,000 for Canadian Arctic.
1997	TAC increased to 275,000 for Canadian waters.
2000	Taking of whitecoats prohibited by condition of license
2003	Implementation of 3 year management plan allowing a total harvest of 975,000 over 3 years with a maximum of 350,000 in any one year.
2005	TAC reduced to 319,517 in final year of 3 year management plan
2006	TAC increased to 335,000 including a 325,000 commercial quota, 6,000 original initiative, and 2,000 allocation each for Personal Use and Arctic catches
2007	TAC reduced to 270,000 including 263,140 for commercial, 4,860 for Aboriginal, and 2,000 for Personal Use catches
2008	TAC increased to 275,000 including a 268,050 for commercial, 4,950 for Aboriginal and 2,000 for Personal Use catches Implementation of requirement to bleed before skinning as a condition of licence
2009	TAC increased to 280,000 based upon allocations given in 2008 plus an additional 5,000 for market development Additional requirements related to humane killing methods were implemented

Table 4. Major management measures implemented for hooded seals in Canadian waters for 1964–2009.

Year	Management Measure
1964	Hunting of hooded seals banned in the Gulf area (below 50oN), effective 1965.
1966	ICNAF assumed responsibility for management advice for northwest Atlantic.
1968	Open season defined (12 March–15 April).
1974–1975	TAC set at 15,000 for Canadian waters. Opening and closing dates set (20 March–24 April).
1976	TAC held at 15,000 for Canadian waters. Opening delayed to 22 March. Shooting banned between 23:00 and 10:00 GMT from opening until 31 March and between 24:00 and 09:00 GMT thereafter (to limit loss of wounded animals).
1977	TAC maintained at 15,000 for Canadian waters. Shooting of animals in water prohibited (to reduce loss due to sinking). Number of adult females limited to 10% of total catch.
1978	TAC remained at 15,000 for Canadian waters. Limited number of adult females to 7.5% of total catch.
1979–1982	TAC maintained at 15,000. Catch of adult females reduced to 5% of total catch.
1983	TAC reduced to 12,000 for Canadian waters. Previous conservation measures retained.
1984–1990	TAC reduced to 2,340 for Canadian waters.
1987	Change in Seal Management Policy to prohibit the commercial hunting of bluebacks and hunting from large (>65 ft) vessels (effective 1988). Changes implemented by a condition of licence.
1991–1992	TAC raised to 15,000.
1992	First Seal Management Plan implemented.
1993	TAC reduced to 8,000. Seal Protection Regulations updated and incorporated in the Marine Mammal Regulations. The commercial sale of bluebacks prohibited under the Regulations.
1995	Personal sealing licences allowed (adult pelage only).
1998	TAC increased to 10,000
2000	Taking of bluebacks prohibited by condition of license.
2007	TAC reduced to 8,200 under Objective Based Fisheries Management based on 2006 assessment
2008	Implementation of requirement to bleed before skinning as a condition of license
2009	Additional requirements implemented to ensure humane killing methods are used