ICES WGHARP REPORT 2013

ICES ADVISORY COMMITTEE

ICES CM 2013/ACOM:20

REF. LRC, RMC

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

26–30 August 2013

PINRO, Murmansk, Russia

ICES International Council for the Exploration of the Sea
CIEM Conseil International pour l'Exploration de la Mer

International Council for the Exploration of the Sea
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

Recommended format for purposes of citation:

ICES. 2013. Report of the Working Group on Harp and Hooded Seals (WGHARP), 26-30 August 2013, PINRO, Murmansk, Russia. ICES CM 2013/ACOM:20. 65 pp. https://doi.org/10.17895/ices.pub.19282244

Contents

Executive Summary

The ICES/NAFO Working Group on Harp and Hooded Seals (WGHARP) met during 26-30 August 2013 at the Knipovich Polar Research Institute of Marine Fisheries and Oceanography (PINRO, Murmansk, Russia. The WG received presentations related to stock identity, catch (mortality) estimates, abundance estimates, and biological parameters of White Sea/Barents Sea, Greenland Sea and Northwest Atlantic Ocean harp and hooded seal stocks, and provided updated catch options for northeast Atlantic harp and hooded seals in response to a request from Norway. The WG concluded their meeting on 30 August. In attendance were scientists representing Canada (2), Greenland (1), Norway (4), and Russia (8), (Annex 1).

Harp Seals have traditionally been managed as three breeding populations based upon whelping areas in the Greenland Sea, White Sea, and two connected areas along the coast of Newfoundland and Labrador and in the southern Gulf of St Lawrence. Despite extensive study, phylogeographic relationships among populations remained uncertain. A new analysis that undertook a complete mtDNA coding-region genomes of 53 individuals from the four areas supports the White Sea, Greenland Sea, and Northwest Atlantic breeding areas as genetically distinct populations.

A pup survey of White Sea/Barents Sea harp seal stock was flown during March 2013, but the results were not available during the meeting. The population model was fitted to the same pup production surveys and reproductive rate information presented at WGHARP 2011 (ICES 2011). Harvest data were updated to 2013. The White Sea/Barent Sea harp seal stock population model estimates a 2013 abundance of 1 221 000 (1 069 800 – 1 372 200) 1+ animals and 198 800 (177 483 – 220 117) pups. Total estimate is 1 419 800 (1 266 910 – 1 572 690). The model at current catch levels, which are essentially 0, indicates an increase in the 1+ population of 13% the next 10 years. Equilibrium catch level is 17 400 (100% 1+ animals). A catch level of 26 650 animals (100% 1+) will bring the population size down to N70 with probability 0.8 within 10 years. This catch level indicates a 8% decrease of the 1+ population in 10 years. The PBR removals are estimated to be 40 430 (14% pups). This catch option indicates a 16% reduction of the 1+ population in 10 years. The working group has used aerial surveys of pups flown between 1998 and 2010 in the formulation of its advice. Surveys prior to 1998 were surveys to count adults. These surveys were found to have been flown prior to peak pupping, and did not take into account that some females are absent from the ice at different times of the day and under different weather conditions. Therefore unless a correction factor can be developed and applied to the pre-1998 surveys, they are not suitable for providing estimates of abundance of seals in the White Sea.

In the Greenland Sea/West Ice population, total catches) were 5,593 harp seals (including 3,740 pups) in 2012, and 16,033 harp seals in the area in 2013 (including 13,911 pups). A new aerial survey to estimate harp seal pup production in the Greenland Sea was flown in 2012 and resulted in an estimate of 89 590 (SE = 12 310, CV = 13.7%) pups. This estimate is slightly, but not significantly lower, than estimates obtained in similar surveys of the area in 2002 and 2007.

The model estimates a 2013 abundance of 534 400 (379 200 – 689 600) 1+ animals and 93 010 (70 210 – 115 810) pups for a total estimate of 627 410 (470 540 – 784 280) seals. This is slightly lower than the 2011 estimate of harp seals in the Greenland Sea of 649 566 (379 031 – 920 101) animals but the differences are not significant. Current catch level indicates an increase in the 1+ population of 21% over the next 10 years. The

equilibrium catch level is 14 600 (100% 1+ animals). A catch level of 21 270 animals (100% 1+) would reduce the population to N70 within 10 years.

Aerial surveys to estimate pup production in the Northwest Atlantic were flown in 2012, but the results for all regions will not be available until the fall of 2012. Estimates from the southern Gulf of St Lawrence are almost half of estimates from 2008. Years with poor ice conditions have been increasing in frequency over the past decade. Ice conditions observed during 2012, were similar to those observed in 1969, 2010, and 2011 and are among the worst on record. This has serious implications for the persistence of breeding harp seals in the southern Gulf of St Lawrence. New research results from the Front show that female attendance on the ice varies with time of day and wind speed. An unusual mortality event was documented in the Northwest Atlantic population in 2010/2011 reports of approximately 300 animals were documented. The cause of these mortalities has not been determined.

Results from a re-analysis of hooded seal pregnancy rate data termed composite pregnancy rates (Pcomp), because they use information on both ovary alternation rates and proportions of multiparous females. The resulting estimates ranged from 0.62 to 0.74 and showed no significant differences between sampling periods. The pregnancy rate for the total sample was 0.68 (95% CI=0.06), which is about 20% lower than the pregnancy rate earlier estimated for Russian samples from 1986-1990, based only on alternation rates. Pcomp does not take into account late term abortions and are therefore maximum estimates. An aerial survey to estimate hooded seal pup production were flown in 2012. These surveys suggest that pup production remains low (13 655 pups, CV=13.8%). These estimates were slightly lower, but not significantly different than estimates obtained from the 2007 survey (16 140 pups, CV=13.3%) .

The Greenland hooded seal population is considered to be data poor. The population model is similar to the model assessing the abundance of the Greenland Sea and the Barents Sea / White Sea harp seal population. Recent estimates of pregnancy rates, appear to be constant around F = 0.7 in the period 1958 – 1999. The model runs indicate a population currently well below N30 (30% of largest observed population size). Under the scenario using a pregnancy rate of F = 0.7 the model predicts a 7% decrease of the 1+ population over the next 10 years. Following the Precautionary harvest strategy previously developed by WGHARP (see ICES2005, 2008), the implication of this is no current catches from the population.

1 Opening of the meeting

The ICES/NAFO Working Group (WG) on Harp and Hooded Seals (WGHARP) met during 26-30 August 2013 at PINRO in Murmansk, Russia. The WG received presentations related to estimates of catch, mortality, abundance, biological parameters and current research of relevance to White Sea/Barents Sea, Greenland Sea and Northwest Atlantic Ocean harp and hooded seal stocks. The WG was requested to provide catch options for northeast Atlantic harp and hooded seals in response to a request from Norway. In attendance were scientists representing Canada (2), Greenland (1), Norway (4), and Russia (8), (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 26 August 2013.

3 Terms of reference

In September 2012 the Norwegian Royal Ministry of Fisheries and Coastal Affairs requested ICES to assess the status of the Greenland Sea and White Sea/Barents Sea harp and hooded seal stocks. Their key request was for the WG to:

a) Review results of 2012–2013 surveys

b) Provide quota advice to ICES/NAFO member states of their harvests of harp and hooded seals as follows (request from Norway):

- an assessment of status and harvest potential of the harp seal stocks in the Greenland Sea and the White Sea/ Barents Sea, and of the hooded seal stock in the Greenland Sea.
- assess the impact on the harp 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 future 1 + population),
  - catches that would reduce the population over a 10-years period in such a manner that it would remain above a level of 70% of current level with 80% probability.

c) Provide advice on other issues as requested

The WG convened at Murmansk, Russia in August 2013 to fulfil this purpose.

4 Harp seals (*Pagophilus groenlandicus*)

4.1 Stock Identity

Harp Seals (Pagophilus groenlandicus Erxleben, 1777) have traditionally been managed as three breeding populations based upon whelping areas in the Greenland Sea, White Sea, and two connected areas along the coast of Newfoundland and Labrador and in the southern Gulf of St Lawrence. Despite extensive study, phylogeographic relationships among populations remained uncertain. Complete mtDNA coding-region genomes (15,825 bp) from each of 53 individuals from the four areas were ex-

amined. The analysis supports the White Sea, Greenland Sea, and Northwest Atlantic breeding areas as genetically distinct populations (Carr *et al*. SEA219).

4.2 The White Sea and Barents Sea Stock

4.2.1 Information on recent catches and regulatory measures

Due to concern over the decline in harp seal pup production in the White Sea since 2004, ICES (2011) recommended that removals be restricted to a level that will maintain a stable population level. This sustainable equilibrium level was estimated to be 15,827 1+ animals (where 2 pups balance one 1+ animal) in the White and Barents Sea in 2012 and 2013. The Joint Norwegian-Russian Fisheries Commission followed this request and allocated 7,000 seals of this TAC to Norway in both years (Annex 8, Table 2). The Russian hunt was intending to focus on beaters but as a result of the Russian ban on catches of harp seals less than 1 year of age that has been in place since 2009, there were no commercial Russian harp seal catches in the White Sea in 2012 or 2013. Local hunters took 9 adult seals for subsistence use in 2012. While one Norwegian vessel had planned to conduct hunting in the southeastern Barents Sea in 2012, this did not occur and so no Norwegian vessels hunted in this area in 2013 (Appendix 7, Table 2; Haug *et al*. SEA 211).

4.2.2 Current research

Lindstrøm *et al*. (SEA 224) presented studies of harp seal foraging behaviour during their intensive summer feeding period in the northern Barents Sea in 1996-2006. Subadult (<150 cm) and adult seals were observed to feed heavily on pelagic crustaceans (particularly krill) – adult seals also ate fish. In terms of biomass, krill was most important (63%) followed by polar cod (16%) and other fish species (10%). The seals targeted primarily the most lipid-rich prey at this time of the year: krill, followed by other crustaceans and polar cod (Grahl-Nielsen *et al*. SEA 223). Other fish species were very lean, and Lindstrøm *et al*. (SEA 224) suggested that availability of high-energetic food in the northern areas in spring and summer presumably provide the energetic advantage necessary to account for the long migrations of harp seals from their more southerly located winter distributions.

Harp seal body condition, estimated from samples taken during spring in 1992-2011, exhibited a slow increase from 1992 to 2001, whereafter a significant decrease to a minimum in 2011 occurred (Øigård *et al* SEA 225). Analyses of relevant covariates indicated that high abundance of krill impacted the seal condition positively, emphasizing the ecological significance of krill as key food for harp seals during summer. High abundances of capelin, polar cod and cod had, however, a negative impact on seal condition. A linear correlation between annual pup production and blubber thickness indicated that recently observed declines in pup production may be associated with changes in body condition of the seals. Seemingly, indirect effects such as competition between harp seals and prey for shared resources such as krill, may have resulted in negative effects on condition with subsequent implications for breeding success.

Two presentations were made by researchers from PINRO that explored the dynamics of the White Sea harp seal population.

PINRO has been assessing the White Sea pup production using multi-spectral aerial surveys since 1998. Surveys flown during 1998-2003 produced pup production estimates that ranged from 287,000 to 340,000. Subsequent surveys in 2004 and 2005 indi-

cated a significant reduction in pup production with a low of 122,000 (± 20,000) in 2005. Pup production remained low in 2008, but appears to have increased slightly based upon surveys to 2010. The reasons for the decline starting in 2004 are not known (ICES 2011), although one hypothesis is that there was a decline in fecundity as a result of an increase in percentage of barren females and/or increase in the age of maturity.

Shafikov (SEA 217) examined the relationships between the proportion of non-pregnant animals (barrenness) and age of maturity on estimates of population size using the formula:

$$S = \frac{3-k}{1-k} * P_0 + \sum_{i=1}^{J} P_i$$

where:

k – the number of barren (non-pregnant) females as a proportion of the number of mature females;
J – the average age of maturity;
P_i – pup production in J-years, preceding the current year
P_0 – pup production in the current year

Derivation of this formula was previously presented to WGHARP (ICES 2009).

This analysis shows that estimates of total population size are very sensitive to changes in the barrenness factor (k) and average age of maturity (J) of harp seal females (Fig. 1). The usefulness of the model could be extended to estimate total abundance if mortality was also incorporated into the model.

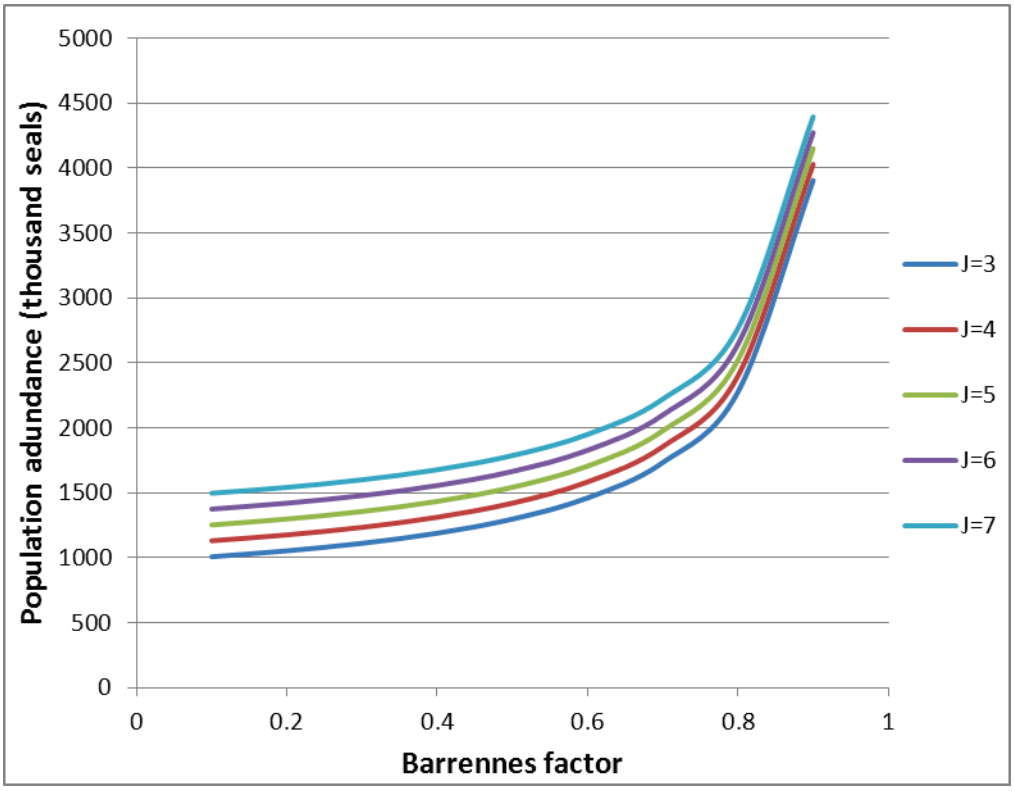

Figure 1. Changes in estimates of White Sea harp seal abundance (y-axis) under different scenarios of proportions of females that are barren (x-axis) and different assumptions of age of maturity (J).

In a second presentation, by Viktor Korzhev, the basic model used to describe the dynamics of the White Sea population (ICES 2011) was modified to account for varying biological parameters. Variations in three parameters, maturation (i.e. age of sexual maturity), natural mortality of pups and female birth rate (F) were studied. The mean age of 50% maturation and maturation ogive were estimated using a logistic curve adjusted to the observed portion of mature animals in samples from the whelping and moulting patches (data from Khuzin 1972, Kjellqwist *et al*. 1995, Timoshenko 1995). Periods of favourable, unfavourable and very unfavourable years for pup survival between 1966 and 2008 were identified based upon a study by Lukin (2005) . Pup natural mortality was assumed to be 0.1 in favourable years, 0.2 – in unfavourable years and 0.3 – in very unfavourable years. Since reproductive data for this population are limited, the dynamics were simulated using data from the Northwest Atlantic harp seal population (Sjare and Stenson 2010). The abundance of the White Sea harp seal population was then estimated under several scenarios including a model with constant values of maturation ogive and birth rate, and a model in which the maturation ogive and the birth rate were allowed to vary. It was found that to describe the pup abundance estimates obtained from the aerial surveys, fecundity in the model for the years 2005-2008 had to decline very sharply. Incorporating smoothed reproductive data from the Northwest Atlantic harp seal population which included a decline in fecundity improved the fit to the survey data. The estimates of population abundance at age 1+ were significantly different in the different scenarios explored and equalled to 1.3-2.1 million animals for 2012 in the model that used the smoothed NWA reproductive data. The impact of the various model approaches on estimates of harvest levels using the model population and PBR were explored. The author concluded that model estimates of harvests generated from the population model were preferable to estimates obtained using PBR since the latter were not sustainable.

4.2.3 Biological parameters

No new information was presented

The WG noted that no biological material has been collected from this area since 2011. The WG **recommends** that efforts be made to obtain samples, particularly to evaluate reproductive rates required for use in the population model, be obtained as soon as possible.

4.2.4 Population assessment

Pup production

Aerial surveys were conducted in 2013 to estimate pup production in the White Sea using the same multi-spectral methods presented to the WG at previous meetings (Shafikov and Egorov SEA 216). Six survey flights (15, 16, 17, 18, 20 and 21 March 2013) were completed. Over 7000 km2 were covered by the survey. The first 5 surveys provided complete coverage of the area. The survey on 21 March provided a second independent coverage of the area where pupping occurred. Ice conditions in 2013 were typical, corresponding to long-term, mean ice conditions. Location of the whelping patch is given in figure 2. More than 16,000 digital photos of the White Sea ice coverage and over 200 Gb of thermal images were obtained. These data are currently under analysis and it is anticipated that the estimates will be available later this year. Taking into account the uncertainties in the trend of pup production for this

population, the WG **recommends** that the results should be presented for review as soon as possible.

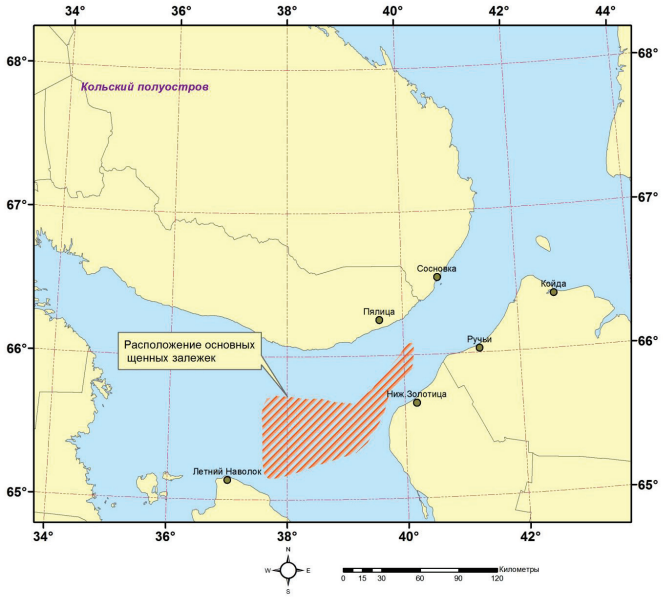

Figure 2. Location of the harp seal whelping patch in the White Sea

Population estimates

An age-structured population dynamics model developed to estimate abundance and provide catch options for harp seals in the White Sea/Barents Sea was presented (Øigård *et al*. SEA215). It incorporates historical catch data (Annex 7, Table 2), time varying reproductive rates (Tables 1,2) and estimates of pup production (Table 3)to estimate the current total population. The model estimates the initial population size (N_0), pup mortality (M_0) and mortality of all seals aged 1 year and older (M_{1+}).

Table 1. Estimates of proportion of females giving birth. Data from ICES (2011).

Year	Estimated F
1990-93	0.84
2006	0.68

Table 2. Estimates of proportions of mature females (p) at ages 4-13 in four historical periods: P_1 = 1962-1972 P_2 = 1976-1985; P_3 = 1988-1993; P_4 = 2006-2009;. Data from ICES (2011).

Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15
P_1	0	0.01	0.17	0.64	0.90	0.98	0.99	1.0	1.0	1.0	1.0	1.0	1.0	1.0
P_2	0	0	0	0.24	0.62	0.81	0.81	0.95	0.98	0.99	0.99	1.0	1.0	1.0
P_3	0	0	0.02	0.08	0.21	0.40	0.59	0.75	0.85	0.91	0.95	0.97	0.98	0.99
P_4	0.01	0.02	0.05	0.11	0.25	0.55	0.90	0.99	1.0	1.0	1.0	1.0	1.0	1.0

Table 3. 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 ICES (2011).

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[a] 339,710[b]	0.098 0.105
2002	20 March	330,000	0.103
2003	18 & 21 March	328,000[c]	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
2010	20-23 March	163,022	0.198

a. 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.

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. 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.

The natural mortality rate M_{1+} determines the survival probabilities $s_{1+}= \exp(-M_{1+})$ and $s_0=\exp(-M_0)$, which are the quantities that appear in the population dynamics equations. M 1+ is assumed to be age independent because available data do not allow for a more detailed age-dependence mortality rate to be estimated.

It is assumed that the population had a stable age structure in year t0 = 1945, i.e.,

$$N_{i,0} = N_{t_0} s_{1+}^{i-1}(1-s_{1+}), \quad i = 1,\ldots, A-1, \tag{1}$$

$$N_{A,0} = N_{t_0} s_{1+}^{A-1}. \tag{2}$$

Here A is the maximum age group containing seals aged A and higher, and N_{t0} is the estimated initial population size in year t_0.

The catch records give information about the following quantities:

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

$C_{1+,t}$ ~ Catch in number of 1+ age group in year t.

In the absence of information about age-specific catch numbers for 1+ seals, we employ pro rata rules in the model (Skaug *et al*., 2007):

$$C_{i,t} = C_{1+,t}\frac{N_{i,t}}{N_{1+,t}}, \quad i = 1,\ldots,A, \tag{3}$$

where $N_{1+,t} = \sum_{i=1}^{A} N_{i,t}$ and $N_{i,t}$ is the number of individuals at age i in year t.

The model has the following set of recursion equations:

$$\begin{aligned} N_{1,t} &= (N_{0,t-1} - C_{0,t-1})s_0, \\ N_{i,t} &= (N_{i-1,t-1} - C_{i-1,t-1})s_{1+}, \quad i = 2,\ldots,A-1, \\ N_{A,t} &= \left[(N_{A-1,t-1} - C_{A-1,t-1}) + (N_{A,t-1} - C_{A,t-1})\right]s_{1+}. \end{aligned} \tag{4}$$

The pup production is given as

$$N_{0,t} = \frac{F_t}{2}\sum_{i=1}^{A} p_{i,t}N_{i,t}, \tag{5}$$

where $N_{i,t}/2$ is the number of females at age i, F_t is the time variant pregnancy rates and pi,t are the time variant maturity curve .

The model also calculates the depletion coefficient D_{1+}, which describes the degree of increase or decrease in the 1+ population trajectory on a 10-year scale,

$$D_{1+} = \frac{N_{1+,2023}}{N_{1+,2013}}. \tag{6}$$

The depletion coefficient is used for finding the equilibrium catch levels. The equilibrium catch level is defined as the catch level that maintains the population size at 2013 level, i.e., the catch level that gives D = 1.

The estimated population sizes, along with the parameters for the normal priors used are presented in Table 4, and the modelled population trajectory is shown in Figure 4. The model is very stiff and the fit to the observed pup production estimates is poor. The modelled total population indicates that the harp seal abundance in the White Sea decreased from 1946 to the early 1960s, but has generally increased since then. The modelled total population in 2013 is estimated to be about 83% of Nmax, which is the historical maximum population size observed/estimated.

Table 4: Estimated mean values and standard deviations of the parameters used in the model. Priors used are shown in brackets.

Parameters	Model estimates	
	Mean	SD
N_{t_0}	1 354 376 (1 000 000)	116 050 (2 000 000)
M_0	0.33 (0.27)	0.05 (0.05)
M_{1+}	0.11 (0.09)	0.01 (0.008)
$N_{0,2013}$	198 800	11 565
$N_{1+,2013}$	1 221 000	77 143
$N_{Total,2013}$	1 419 800	78 005

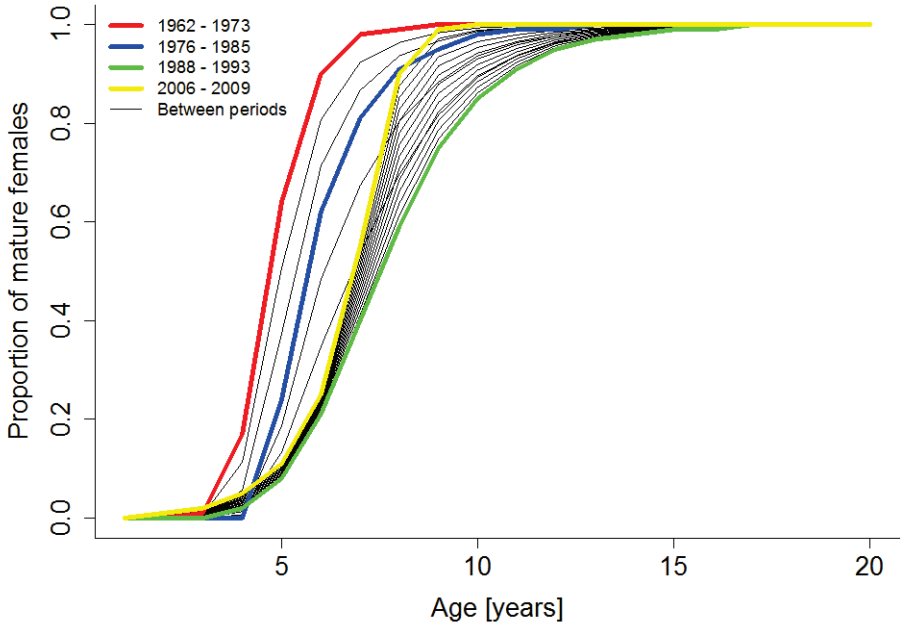

Figure 3: Proportion of mature females among harp seals in the East Ice in four periods. Values are taken from Table 1.

The model is stable for various choices for initial values of the estimated parameters. Changing the mean of the prior of M_{1+} from 0.09 to 0.11 and the mean of the prior of M_0 from 0.27 to 0.11 (a change of about 18%) caused a 5% change of the total abundance estimate. The modelled total abundance in 2013 was then estimated to be at N_{70} level. The prior for M_0 is non-informative, whereas the prior for M_{1+} is relatively informative. The model is stable for different choices of initial values of the estimated parameters. The prior for the M_{1+} is fairly precise, with a standard deviation of 0.008.

Changing the standard deviation of the prior to 0.05, rendering the prior relatively non-informative, caused a 3.8% change in the estimated 2013 total abundance.

The model estimates a 2013 abundance of 1 221 000 (1 069 800 – 1 372 200) 1+ animals and 198 800 (177 483 – 220 117) pups. The total estimated population is 1 419 800 (1 266 910 – 1 572 690)(Fig. 4).

The lack of historical data on pregnancy rates makes the population model stiff, and unable to capture the dynamics of the survey pup production estimates. The model projects future population size, assuming a fecundity rate of 64%, although the pup production data suggests that fecundity may be lower. If so, the model may be overestimating the future fecundity and underestimating the impact of catches.

Pregnancy rates have shown marked inter-annual changes , resulting in significant impact on the population modelling (Sjare and Stenson 2010, Stenson and Wells 2010). In the Northwest Atlantic, where annual estimates of fertility are available for the harp seal population over a period spanning from 1954 to date, the proportion of females that were pregnant has been observed to vary from 40% to more than 85% between different years (Sjare and Stenson 2010, Stenson and Wells 2010). A decline in the reproductive status of females may explain the sudden decrease in pup production observed for the Barents Sea / White Sea harp seal population after 2003, and reducing fecundity in the population model did in fact produce estimates able to mimic the pup production changes observed (ICES 2011). A drop in the body condition of the adult seals has been observed over the same time period, suggesting that if the condition of seals has an influence on the pregnancy rates, such a change in fecundity may have occurred (ICES 2011, Øigård *et. al.*, 2013). Future work should study the relationship between condition of seals and reproduction rates further.

Given the difficulties in fitting to pup production estimates from the White Sea population, the WG **recommends** that different approaches to modify the model be explored to improve the fit to the data**.**

In their studies of the Barents Sea / White Sea harp seal population, Gaydenok *et al*. (2012) suggested that the pup production estimates obtained in 1998-2004 were overestimates, presumably due to errors in the surveys and/or in the subsequent analyses. This conclusion is based on their observation that there is a poor fit to population model trajectories projected from abundance levels based on surveys of pupping females around 1990. Gaydenok *et al*. (2012) using exponential curves with varying growth rates. The growth rates required to obtain reasonable fits to the lowest estimate, were considered to be unrealistically high given the poor resource levels in the Barents Sea at that time.

All Russian aerial harp seal pup production surveys in the White Sea from 1998 to 2010 are based on direct pup counts (ICES 2011). In the period 1963-1991, however, annual pup productions were estimated from aerial photographic surveys of adult harp seal females on the ice during the whelping period (Potelov *et al*. 2003). However, coverage during some of these surveys was incomplete and it was well known that as much as 45-50% of the females may have been in the water during the surveys (Popov 1966). Potelov *et al*. (2003) suggested that the timing of the surveys was generally very early as compared with the whelping period. Perry *et al* (SEA220) showed that the proportion of females present on the ice will vary with time of day, temperature and wind speed. None of these early survey estimates were corrected for such errors, and therefore are unreliable, negatively biased estimates of pup production. In contrast, the series of estimates beginning in 1998, can be considered to be reliable estimates of pup production.

Catch Options

The population model used by the WG in 2009 was not considered appropriate, and the working group felt that it could not be used to evaluate the requested catch options (ICES 2009). The only alternative available was to provide sustainable catches option based upon the Potential Biological Removal (PBR) approach (ICES 2005). In 2011 the model was changed to include time-variant biological parameters and was then used by the WG to provide advice on the requested catch options. However, the last reproductive rates available are based on data from 2006 (ICES 2011), i.e. more than 5 years old. Based on the Precautionary Approach criteria adopted by ICES for advice on harp and hooded seals (ICES 2009-check), this population should be classified as data poor. Therefore the PBR approach was also considered . Options for various catch scenarios are given below.

1. Current catch level (average of the catches in the period 2008 – 2012).
2. Equilibrium catch levels which are defined as the (fixed) annual catch level that stabilizes the future 1+ population under the estimated model.
3. Catches that would reduce the population to N_{70} with probability 0.8 over a 10-years period.
4. Potential Biological Removals level.

The Potential Biological Removals has been defined as:

$$PBR = \frac{1}{2} R_{\max} F_r N_{\min},$$

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. Given the still unexplained drop in pup production observed beginning in 2004, the recovery factor F_r was set to 0.5. The PBR catch option assumes that the age structure of the removals is proportional to the age composition of the population. A catch consisting of a higher proportion of pups would be more conservative, but a multiplier to convert age 1+ animals to pups is inappropriate for the PBR removals.

The estimates for the various catch options are given in Table 5. Current catch level indicates an increase in the 1+ population of 13% over the next 10 years. The equilibrium catch level is 17 400 (100% 1+ animals). A catch level of 26 650 animals (100% 1+) will bring the population size down to N_{70} with a probability 0.8 within 10 years. This catch level indicates a 8% decrease in the 1+ population in 10 years. The PBR removals are estimated to be 40 430 (14% pups). This catch option indicates a 16% reduction of the 1+ population in 10 years.

Table 5. Catch options with relative 1+ population size (D1+) in 10-years (2023) for harp seals in the White Sea.

Catch option	Proportion pups in catches	Pup catch	1+ catch	Total catch	D_{1+} (95% CI)		
Current level	97.6%	2 667	65	2 732	1.01	1.13	1.25
Equilibrium	97.6%	31 950	786	32 736	0.88	1.00	1.12
Equilibrium	0%	0	17 400	17 400	0.88	1.00	1.12
Reduce to N_{70} [a)]	97.6%	48 580	1 195	49 775	0.81	0.93	1.05
Reduce to N_{70}[a)]	0%	0	26 650	26 650	0.81	0.93	1.05
PBR	14.0%	5 660	34 770	40 430	0.71	0.84	0.96

[a)] Catches that would reduce the population to 70% of current level with 0.8 probability over a 10 years.

The WG expressed concerns on the high removals and declining population resulting from the PBR estimations. The possible use of a recovery factor less than 0.5 was discussed, but in conclusion the WG agreed that the estimated equilibrium catches were the most preferred option. The current equilibrium option is slightly higher than the option given in 2011. This is possibly a result of no, or very low catches in 2012 and 2013.

Hammill and Stenson (2010) explored the impact of extrapolating catches on our ability to monitor changes in the population given the precision and frequency of pup production surveys. They found that catches should be projected over a period of at least 15 years to determine their impact on the population. Therefore, the WG r**ecommends**, that in the future catch scenarios be explored over a 15 year period, rather than the current 10 years. This recommendation applies to all of the populations considered by WGHARP.

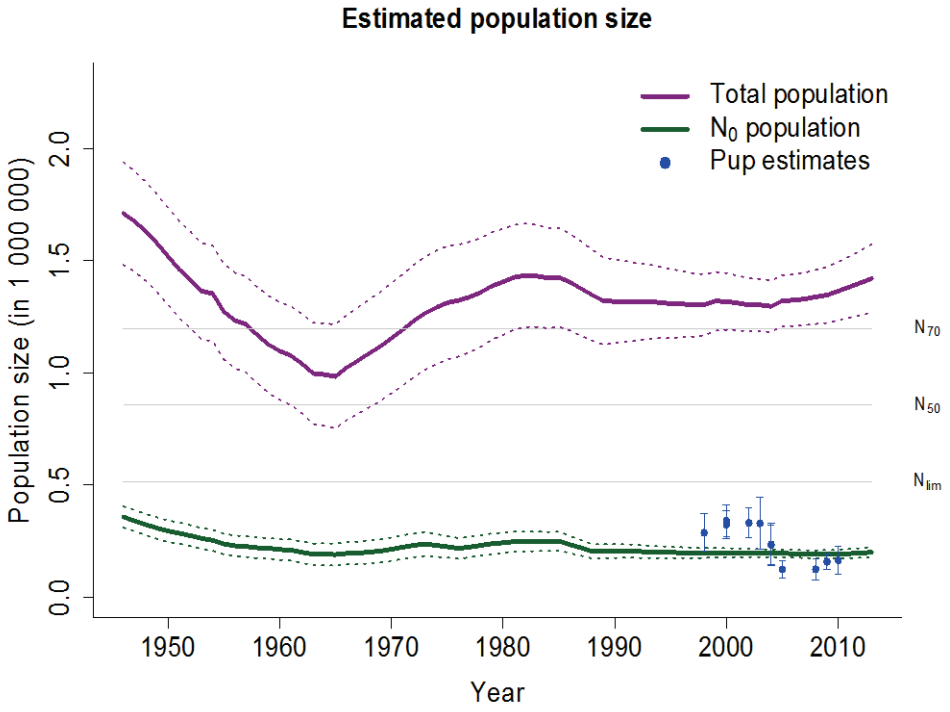

Figure 4: Modelled population trajectories for pups and total population (full lines) and 95% confidence intervals (dashed lines). N_{70}, N_{50}, and N_{lim} denote the 70%, 50% and 30% of the historical maximum population size, respectively.

4.3 The Greenland Sea Stock

4.3.1 Information on recent catches and regulatory measures

Based on advice from WGHARP (ICES 2011) the 2012 and 2013 TAC for harp seals in the Greenland Sea was set at 25 000 1+ animals (where 2 pups balance one 1+ animal), i.e. the estimated removal level that would reduce the population by 30% over the next 10 year period (Appendix 8, Table 1) . The total removals of Greenland Sea harp seals in 1946-2013 are shown in Annex 7, Table 1 . For economic reasons, Russia has not participated in this area since 1994. Total catches in 2012 (performed by two vessels) were 5,593 harp seals (including 3,740 pups), whereas 4 vessels took 16,033 harp seals in the area in 2013 (including 13,911 pups). The removals represented 22% and 54% of the identified sustainable levels in 2012 and 2013, respectively (Haug et al. SEA211).

4.3.2 Current research

A time-series of the relative proportions of ringed seal (*Pusa hispida*), harp seal Pagophilus groenlandicus), hooded seal (*Cystophora cris*tata), bearded seal (Erignathus barbatus), walrus (*Odobenus rosmarus*) and narwhal (Monodon monoceros) in the polar bear diet estimated from their fatty-acid composition (McKinney *et al*. SEA 222). This study indicate a strong trend of less ringed seal, but more hooded seals in the diet. The increase may also include an increase in harp seal as harp and hooded seals are difficult to distinguish by fatty acids.

Foote *et al* (SEA 228) examined killer whales caught in southeast Greenland. They reported seals in their stomach of animals that are part of the group called Norway

herring-eating killer whales. Some of the biopsy samples retained from killer whales from Iceland, British Isles and North Sea also belong to that group. Rosing-Asvid noted that catches of killer whales in Greenland water has gone from being a rare event to a relative frequent event, especially in southeast Greenland. The stomach contents of killer whales caught in southeast Greenland indicate that marine mammals, particularly harp seal pups of the year, seem to be important in the diet. This new trend in prey preference along with an apparent increase in the local abundance of killer whales may result in increased harp seal mortality.

4.3.3 Biological parameters

No new information.

4.3.4 Population assessment

Pup production estimation

In the period 18 March to 1 April 2012 IMR conducted aerial surveys in the Greenland Sea pack-ice (the West Ice), to assess the pup production of the Greenland Sea populations of harp and hooded seals (SEA 212, Øigård *et al*., 2013). Two fixed-wing aircraft, stationed in Constable Pynt (East-Greenland) and Akureyri (Iceland), were used for reconnaissance flights and photographic surveys along transects over the whelping areas. A vessel based helicopter also flew reconnaissance flights, and was subsequently used for monitoring the distribution of seal patches and age-staging of the pups. The reconnaissance surveys were flown between 18 March - 1 April in an area along the eastern ice edge between 67°55'and 74°10'N. The ice cover was narrow and the edge was close to the Greenland coast in 2012. The reconnaissance surveys usually flown at altitudes ranging from 160 - 300 m were adapted to the actual ice configuration. East-west transects spaced 5 or 10 nm apart were flown from the eastern ice edge over the drift ice to the west usually 20-30 nautical miles (or longer). Harp seal pups were first observed on 19 March in an area between 73º00'N and 73º18'N; 14º28'W and 15º05'W (Patch A) and on 21 March in area between 72º00'N and 72º25'N; 15º30'W and 17º00'W (Patch B). These two groups drifted together and were subsequently treated as a single patch. Data from the staging surveys were used to estimate the temporal distribution of births. The temporal distribution of births was used to correct the abundance estimates obtained for seals that might not been born yet, or already left the ice at the time of the photographic survey.

Both aircraft were equipped with Vexcel Ultracam Xp digital cameras, which provided multichannel images (Red Green Blue Infrared). On 28 March, a total of 27 photo transects, spacing 3 nautical miles, were flown using both aircrafts in the area between 70º43'N / 18º 31' - 18º 15' W and 72º 01'N / 17º 29' - 17º 29 W. The survey covered the entire area of the merged patches A and B. Coverage along transects was 80-90 % , resulting in a total of 2792 photos. The total pup production estimate obtained for harp seals was 89 590 (SE = 12 310, CV = 13.7%). This estimate is slightly, but not significantly lower, than estimates obtained in similar surveys of the area in 2002 and 2007.

Population assessment

The population model (SEA 213) is similar to the model used to assess the abundance of the Barents Sea / White Sea harp seal population (SEA 215).

The model makes use of historical values of the pregnancy rate *F* (Table 6) available from a Russian long term data set (1959 - 1991), (Frie *et al.* 2003) and later updated

with Norwegian data for 2008 and 2009 (ICES 2011). The long term data set on pregnancy rates relies on the assumption that pregnancy in the previous cycle can be estimated based on the presence/absence of a large luteinised *Corpus albicans* (LCA) in the ovaries of females sampled in April-June (ICES 2009). In periods where data are missing, a linear transition between estimates was assumed. Figure 5 shows the available historical pregnancy rates and the linear transition in periods with missing data.

Table 6. Reproduction rates, F_t, for harp seals in the Greenland Sea. From (ICES, 2011).

Year	Pregnancy rate	Standard Deviation
1964	0.92	0.04
1978	0.88	0.03
1987	0.78	0.03
1990	0.86	0.04
1991	0.83	0.05
2008	0.80	0.06
2009	0.81	0.03

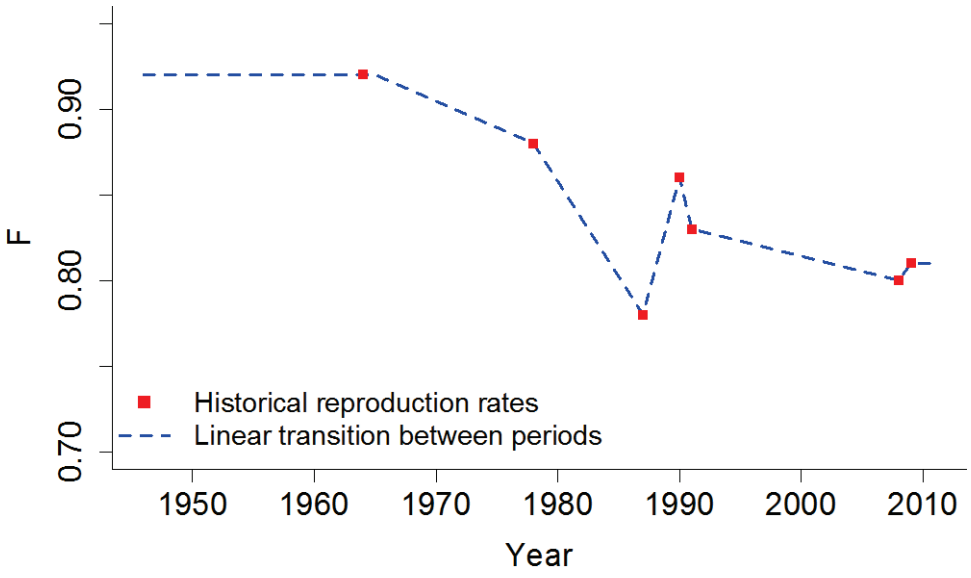

Figure 5. Historical reproduction rates *F* and linear transitions in periods with missing data. Values taken from Table 6.

The model also incorporates a maturity curve $p_{i,t}$ based upon data collected 1959-1990 and in 2009 (Table 7). A linear transition between the two curves was assumed.

Table 7. Estimates of proportions of mature females (pi,t) from the Greenland Sea. The P1 estimates are from the period 1959 - 1990 (ICES, 2009) and the P2 estimates are from 2009 (ICES, 2011).

Age	1	2	3	4	5	6	7	8	9	10	11	12	13
P1	0	0	0.06	0.29	0.55	0.74	0.86	0.93	0.96	0.98	0.99	1.00	1.00
P2	0	0	0	0	0.06	0.28	0.55	0.76	0.88	0.95	0.98	0.99	1.00

Pup production estimates are available from mark-recapture estimates (1983-1991, see Øien and Øritsland 1995) and aerial surveys conducted in 2002 (Haug *et al*., 2006), 2007 (Øigård *et al*., 2010), and 2012 (SEA 212, Øigård *et al*., 2013) (Table 8). Catch levels for the period 1946 – 2013 are presented in (Appendix 7, Table 1).

Table 8. Estimates of Greenland Sea harp seal pup production (ICES 2011, Øigård *et al*., 2010, Øigård *et al*., SEA 212). The data from 1983-1991 are mark-recapture estimates; those from 2002, 2007 and 2012 are from aerial surveys.

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
2012	89 590	0.137

The estimated population sizes and parameters used in the model, along with the normal priors, used are presented in Table 9. The modelled population trajectory is shown in Figure 6. The model estimates were stable for various choices of initial values.

Changing the mean of the prior of M_{1+} from 0.08 to 0.10 and the mean of the prior of M_0 from 0.24 to 0.3 (a change of about 18%) caused a 2% change of the total abundance estimate.

The model trajectory suggests an increase in the population abundance from the 1970s to the present 2013 abundance of 534 400 (379 200 – 689 600) 1+ animals and 93 010 (70 210 – 115 810) pups. The total population estimate is 627 410 (470 540 – 784 280) seals. This is slightly lower than the 2011 estimate of harp seals in the Greenland Sea of 649 566 (379 031 – 920 101) animals (ICES 2011), but the estimates are not significantly different.

The population model had difficulty in capturing the dynamics of the pup production estimates. The predicted population trajectories from the model are driven by the mark-recapture estimates of pup production from the 1980s and early 1990s. There is considerable uncertainty associated with these estimates. Treating these estimates differently could change our predictions of the trajectory of the population. The WG recommended that if possible the mark-recapture data be updated with new information obtained since the original analyses were completed.

Table 9: Estimated mean values and standard deviations of the parameters used in the model. Priors used are shown in brackets.

Parameters	Model estimates	
	Mean	SD
N_{t_0}	260 167 (900 000)	22 268 (900 000)
M_0	0.28 (0.24)	0.19 (0.2)
M_{1+}	0.11 (0.08)	0.02 (0.1)
$N_{0,2013}$	93 010	11 631
$N_{1+,2013}$	534 300	79 186
$N_{Total,2013}$	627 410	80 036

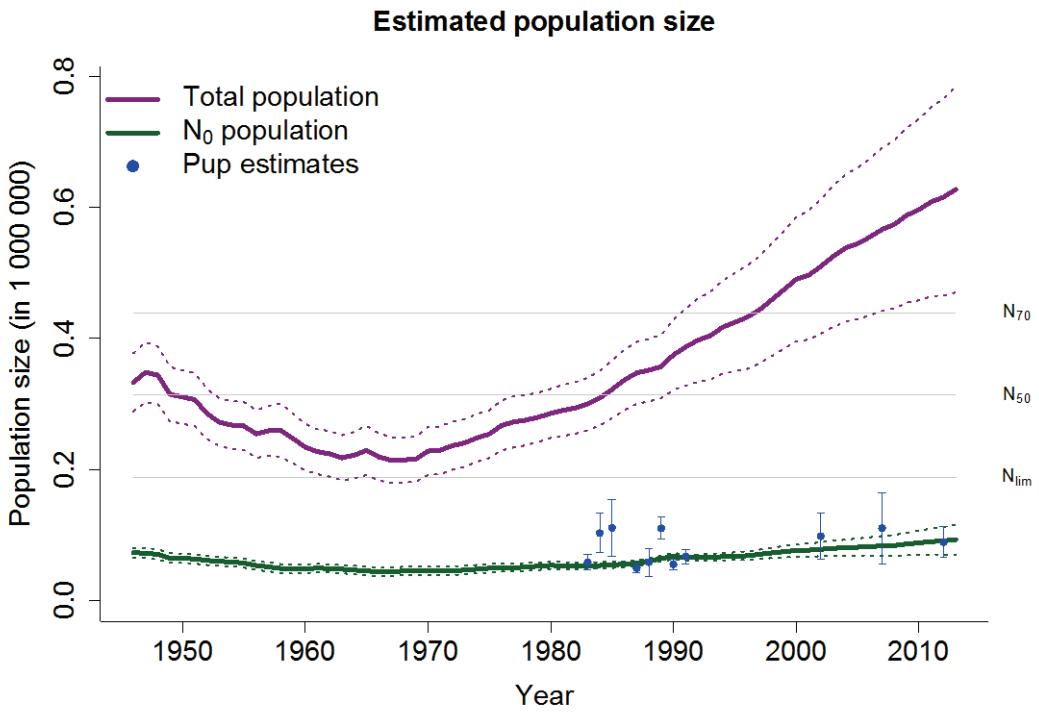

Figure 6. Modelled population trajectories for Greenland Sea harp seal pups and total population (full lines) and 95% confidence intervals (dashed lines). N_{70}, N_{50}, and N_{lim} denote the 70%, 50% and 30% of the estimated maximum population size, respectively.

Catch Options

The WG considered the Greenland Seal harp seal population as data rich, and above the N_{70} level (i.e., more than 70% of known maximum abundance measured) as defined by ICES (2006). Therefore, catch advice can be provided with the use of an appropriate population model.

Options for various catch scenarios of harp seals in the Greenland Sea are given below.

Current catch level (average of the catches in the period 2008 – 2012);

Equilibrium catches which are defined as the (fixed) annual catch level that stabilizes the future 1+ population under the estimated model;

Catches that would reduce the population to N70 with probability 0.8 over a 10-year period.

The estimates for the various catch options are given in Table 10. Current catch level indicates an increase in the 1+ population of 21% over the next 10 years. The equilibrium catch level is 14 600 (100% 1+ animals). A catch level of 21 270 animals (100% 1+) is estimated to reduce the population but keep it above N_{70} with a probability of 0.8.

Table 10. Catch options with relative 1+ population size (D_{1+}) in 10-years (2023) for harp seals in the Greenland Sea.

Catch option	Proportion pups in catches	Pup catch	1+ catch	Total catch	D_{1+} (95% CI)		
Current level	59.9%	3 557	2 384	5 941	1.06	1.21	1.36
Equilibrium	59.9%	12 237	8 192	20 429	0.82	1.00	1.18
Equilibrium	0%	0	14 600	14 600	0.82	1.00	1.18
Reduce to N70 [a]	59.9%	18 562	12 426	30 988	0.64	0.85	1.06
Reduce to N_{70}[a]	0%	0	21 270	21 270	0.67	0.87	1.07

[a] **Catches that would reduce the population to 70% of current level with 0.8 probability over a 10 years.**

4.4 The Northwest Atlantic Stock

4.4.1 Information on recent catches and regulatory measures

Prior to 2006, the Total Allowable Catch (TAC) for harp seals in the Canadian commercial hunt was based upon a management plan that allowed for a total of 975,000 seals over 3 years with a maximum of 350,000 in any one year (Appendix 8,Table 3). After 2005, TACs were set annually to ensure that the population did not decline below the precautionary reference level (i.e. N70 or 70% of the maximum population size) within a 15 year period. The quota of 325,000 for 2006, was lowered to 270,000 in 2007. It was then raised slightly to 275,000 and 280,000 in 2008 and 2009, respectively. The TAC was further increased to 330,000 in 2010 and 400,000 in 2011. This quota was maintained for 2012 and 2013.

The TAC includes allocations for aboriginal harvesters (6,840 since 2011), development of new products (20,000) and personal use (2,000). There is no specific allocation or quotas for catches in Arctic Canada. Catches have steadily declined since 2006 when 354,867 harp seals were reported taken (Appendix 7, Table 3)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. Quotas have been increased, but catches in recent years have been extremely low. In 2011, only 40,389 (10.1% of the TAC) were taken due to a combination of poor ice condi-

tions, reduced effort and alternate fisheries. Since then, catches increased slightly reaching 90,703 (22.7% of the quota) in 2013.

The vast majority of harp seals taken in the Canadian commercial hunt were young of the year. Since 2008 they have accounted for over 99% of the reported catch.

The Greenland catches of harp seals from the west Atlantic population seems to have stabilized at a relative high level around 70-90.000, which was reached in the last part of the 1990s. Catches of harp seals in northeast Greenland is still small (most years below 100) and fluctuating, whereas catches in Southeast Greenland, which are a mixture of seals from the west Atlantic and the Greenland Sea populations, has been declining in recent years (see the time-series in table Appendix 7, table 5).

4.4.2 Current research

Research on density dependent impacts on reproductive rates and condition of NWA harp seals is continuing. Since the mid 1980s, condition and reproductive rates of harp seals have been declining. Interannual variability in pregnancy rates has also increased significantly. Modelling the impact of a wide range of possible factors indicated that the general decline in fecundity can be explained by the observed population increase while the interannual variability is in response to changes in late term abortions which, in turn, are influenced by changes in capelin (their major prey) availability. The abundance of capelin, a key prey of harp seals, has been shown to be correlated with the timing of ice retreat. Although the condition of adult female seals that are not pregnant has declined, the condition of pregnant females has not. This suggests that females that are in good condition maintain their pregnancy while those that do not have sufficient energy reserves may not become pregnant or may terminate their pregnancy by aborting the foetus.

To determine the proportions of females that may be present on the ice, female attendance and nursing patterns under varying environmental conditions were examined (Perry *et al* SEA220). Behavior of 159 harp seal mother-pup pairs off northeastern Newfoundland was recorded every three minutes during daylight hours. Air and water temperature, and wind speed were recorded at the beginning of each observation session. GAMM models were constructed to examine the importance of these variables in predicting attendance and nursing patterns. The best model for predicting attendance included time of day, air temperature, wind speed and the interaction between wind and air temperature. The best model for predicting nursing included wind speed, air temperature, and time of day. Although there was a diurnal pattern in attendance and nursing, they were also affected by environmental conditions. The likelihood that a female was on the ice and attended her pup decreased, while the probability that attended pups were nursed increased, when they encounter high wind speed and low air temperatures. These findings suggest that although fewer females come out of the water, or remain on the ice, to attend their pups in unfavorable climatic conditions, those that do, are there primarily to nurse their pups. These results support observations by other researchers who have reported similar changes in the proportion of females on the ice of the White Sea and in the Gulf of St. Lawrence.

Photographic and visual aerial surveys to determine pup production of Northwest Atlantic harp seals were carried out in February and March 2012. Preliminary estimates of pup production in the southern Gulf of St. Lawrence based on surveys flown between 27 February and 4 March 2012 were presented (Stenson *et al* SEA221). Visual surveys resulted in pup production estimates ranging from 117,600

(SE=31,800) to 137,300 (SE=48,400) animals after correcting estimates for pups born after the surveys were flown. Photographic estimates varied from a low of 59,100 (Se=8,500) from a survey flown on 4 March to 110,400 (SE=19,900) pups from a survey flown on 2 March. The 4 March estimate was not considered to be valid as data on the drift of the ice suggests that some of the whelping seals photographed on 2 March were missed. Also poor ice conditions may have resulted in high mortality among pups. Excluding this survey, the estimated pup production in the southern Gulf was 114,900 (SE=15,000) animals. This is significantly lower than the number of pups estimated in 2004 and 2008. It is not clear if this decline is a result of whelping seals moving out of the southern Gulf or an overall decline in the number of pups born to this component of the population. Years with poor ice conditions have been increasing in frequency over the past decade. Ice conditions observed during 2012, were similar to those observed in 1969, 2010, and 2011 and are among the worst on record. If these conditions continue this would have serious implications for the persistence of breeding harp seals in the southern Gulf of St Lawrence.

Stenson (SEA229) described an unusual morality event observed among harp seals in the Newfoundland area in the winter of 2010/2011 and spring of 2011. Reports of dead, adult harp seals washing ashore along southern Labrador and in the Strait of Belle Isle area were received during December 2010 and January 2011. The condition of the seals and size of the foeti indicate that the deaths did not all occur at one time, but were spread over at least one month. The seals likely died near to where they came ashore; there was no sign that they had been in the water for any length of time (i.e. relatively little sign of decomposition visible in most seals). The majority of reports and photos indicated that the dead seals were adult harp seals in good condition. Only two bedlamers (immature) were observed. With the exception of one bearded seal, no other species of seals were reported.

A sample of 16 seals was recovered for examination. Eleven were mature females of various reproductive status. There were no signs of trauma, injury or damage (e.g. net marks) on any of the seals and they appeared healthy with normal blubber thickness for this time of the year. Gross examination and histopathology could not identify a cause of death. Tests for Phocine Distemper Virus (PDV), Brucella, Influenza A and biotoxins were all negative. Cause of death could not be determined; there were no signs of an infectious disease or trauma. However, the poor preservation of the animals recovered and the lack of unfrozen samples increased the difficulty of determining cause of death.

In late March 2011, additional reports of approximately a dozen dead and dying seals along the east coast of Newfoundland and on Miquelon Island (south of Newfoundland) were received. A sample of 3 dead and dying seals were examined by a veterinary pathologist. The two live seals were lethargic and had moderate respiratory distress. No lesions or signs of injury were present on any of the seals. Gross pathology and histopathology did not identify a cause of mortality. Tests on fresh tissues from these animals Phocine Distemper Virus and Influenza A were negative. Because the seals showed some signs that suggest death could have been due to an unknown virus, several attempts were made to isolate a virus, including a primary seal cell line. However, all attempts were unsuccessful and no viruses could be isolated.

It is unknown if the deaths that occurred during the winter were caused by the same agent as the deaths in the spring. Also, the number of seals that died cannot be estimated. Approximately 300 were reported washing ashore in the few communities present in this area and local hunters reported the remains of a large number of seals

in the woods the following spring. Given the relatively small proportion of dead seals that may have washed ashore and been observed/detected, a significant number of harp seals may have died during this event.

4.4.2 Biological parameters

No new data are available at this time

4.4.3 Population assessment

Pup production

A survey of the Northwest Atlantic harp seal population was flown during March 2012, but final estimates are not available at this time.

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 Appendix 8, Table 1). This advice was immediately implemented. The total removals of Greenland Sea hooded seals in 1946-2013 are shown in Annex 6, Table 1. Total catches for scientific purposes (all taken by Norway, Russian sealers did not operate in the Greenland Sea) in 2012 and 2013 (Annex 6, Table 1) were 21 (including 15 pups) and 22 (including 15 pups), respectively. Catches from northeast Greenland have only averaged 5 during 2006-11, which is about 20% of the average during 1993-2005 (the first 13 years with the present system for collecting catch statistics)(Appendix 6, Table 3).

5.1.2 Current research

A study by Nymo *et al*. (SEA_230) investigated seroprevalence of Brucella pinnipedialis in Greenland Sea hooded seals. Pups (< 1 month) had a substantially lower probability of being seropositive (2.5 %, n=159) than yearlings (35.3 %, n=17), suggesting that exposure occurs post weaning. For seals older than one year, seroprevalence decreased with age, and there were no seropositives older than five years. No significant relationship was observed between Brucella-serostatus and body condition or parity status (based on the presence of Corpora albicantia). The authors hypothesise that young hooded seals are likely exposed to B. pinnipedialis through prey, with a subsequent clearance of infection.

5.1.3 Biological parameters

Frie (SEA 227) presented ovary based pregnancy rates for hooded seal females sampled in Greenland Sea breeding patches over the periods 1958-62 (n=53), 1978-80 (n=134), 1982-85 (n=109), 1987 (n=269) and 1999 (n=143). The estimates are based on a method developed and presented by Frie *et al*. (2012, SEA_231). They are termed composite pregnancy rates (Pcomp), because they use information on both ovary alternation rates and proportions of multiparous females. The resulting estimates ranged from 0.62 to 0.74 and showed no significant differences between sampling periods. The average pregnancy rate for the total sample was 0.68 (95% CI=0.06),

which is about 20% lower than the pregnancy rate estimated earlier for Russian samples from 1986-1990, based only on alternation rates. Ovary based pregnancy rates do not take into account any potential late term abortions and are therefore maximum estimates.

5.1.4 Population assessments

Pup production estimation

Results from the Norwegian survey of the Greenland Sea carried out in 2012 (described in the section on Greenland Sea harp seals xxx) were presented (SEA 212). No distinct hooded seal whelping concentrations were detected, only scattered hooded seal families and, subsequently, solitary bluebacks over a relatively large area. The hooded seals were mixed with the harp seals in the whelping patch and covered by the photographic survey carried out 28 March.

Results from the staging flights suggest that the majority of hooded seal females whelped between 20 and 29 March, peaking on 24 March. The estimated temporal distribution of births was used to correct the abundance estimates. The total estimate of hooded seal pup production was 13 655 (SE = 1 900, CV = 13.9%), which is lower than estimates obtained from comparable surveys in 2005 and 2007, but the differences were not significant.

The extensive reconnaissance surveys conducted in the period 18 March to 1 April of all areas historically used by hooded seals in the Greenland Sea reduced the likelihood of missing major whelping concentrations in 2012. Difficult weather conditions meant that a small number of pups may not have been surveyed in the very open ice fringes northeast of the survey area, but this is not considered to be significant.

Population assessment

Results from the 2012 pup survey suggest that pup production remains low and was significantly lower than observed in the 1997 survey (23 762 pups, CV = 19.2%)(Table 11)(Øigård *et al*. SEA 212). The survey pup production estimates found in Table 11 are slightly different from estimates found in previous reports. The WG noted that the estimates reported for the 1997 and 2005 surveys in previous reports were incorrect.

Table 11. Estimates of Greenland Sea hooded seal pup production , based on data from ICES (2011), Salberg et al., 2008 and Øigård et al., SEA 212).

Year	Estimated Number of Pups	Coefficient of Variation.
1997	23 762	0.192
2005	15 250	0.228
2007	16 140	0.133
2012	13 655	0.138

The population model used to assess the abundance is an age- structured population dynamics model, using historical catch data and estimates of pup production to estimate the current total population (Øigård *et al*. SEA 214). The model is similar to the model assessing the abundance of the Greenland Sea and the Barents Sea / White Sea harp seal population (Øigård *et al*. SEA 213, SEA 215). The model uses empirically based maturity curves and was run for three different scenarios of pregnancy rates, F = 0.5, F = 0.7 and F = 0.9 (Table 11).

The analysis of Frie (SEA 227) indicated that pregnancy rates, remained constant around F = 0.7 in the period 1958 – 1999. This is lower than the estimate of F=0.9 used by the WG in its 2011 report. The difference resulted from a change in the method used to determine pregnancy rates.

Under the scenario of F = 0.7 the model estimates a 2013 pup production of 14 010 (SE=1 622), a 1+ population of 68 820 (SE=7 862), for a total population of 82 830 (SE=8 028) and predicts a 7% decrease of the 1+ population over the next 10 years. As a result of incorporating the most recent pup production estimates, the population estimates from the model were lower than obtained in 2011 (ICES 2011).

Catch options

All model runs indicate a population currently well below N30 (30% of largest observed population size)(Fig. 7). Following the Precautionary harvest strategy previously developed by WGHARP (see ICES2005, 2008), no catches should be taken from this population.

Table 11: Model estimates and standard deviation of the parameters used in the model for various choices of the reproduction rate *F*. Priors used are shown in brackets.

Parameters	F = 0.5		F = 0.7		F = 0.9	
	Mean	SD	Mean	SD	Mean	SD
N_{t_0}	1 290 620 (90000)	459 220 (90000)	1 086 890	394 940	930 610	337 060
M_0	0.33 (0.33)	0.05 (0.05)	0.34	0.02	0.34	0.05
M_{1+}	0.14 (0.11)	0.02 (0.05)	0.17	0.05	0.19	0.02
$N_{0,2013}$	13 850	1 548	14 010	1 622	14 230	1 680
$N_{1+,2013}$	85 220	9 427	68 820	7 862	59 700	6 937
$N_{Total,2013}$	99 070	9 553	82 830	8 028	73 930	7 137

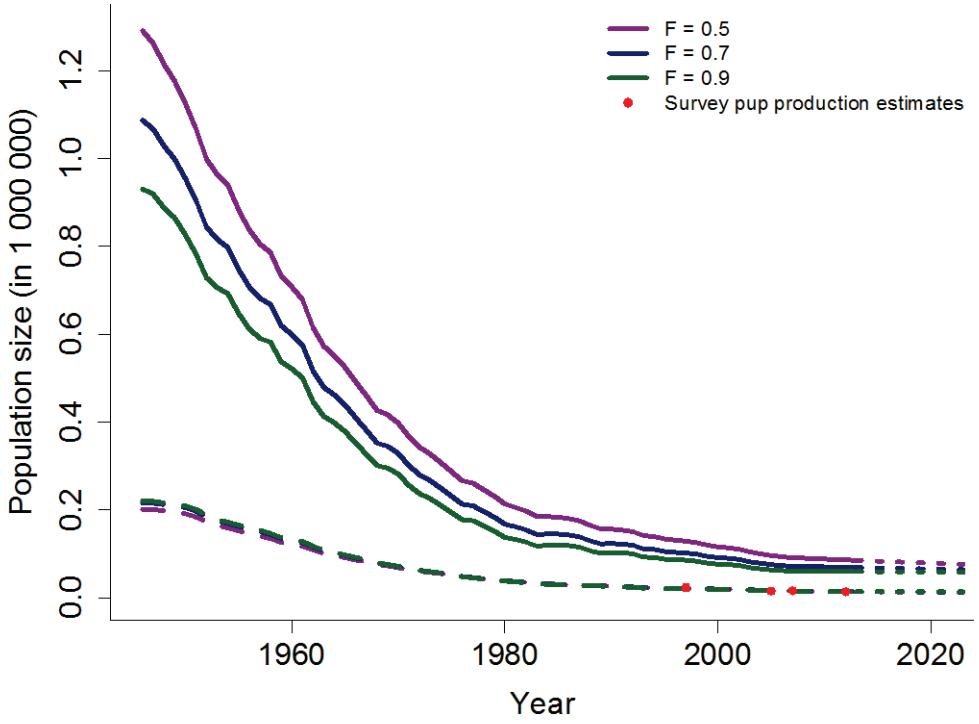

Figure 7: Modelled population trajectories for pups (dashed lines) and 1+ population (full lines) and 95% confidence intervals (dotted lines).

5.2 The Northwest Atlantic Stock

5.2.1 Information on recent catches and regulatory measures

Under the Canadian Atlantic Seal Management Strategy (Hammill and Stenson 2007, 2009), Northwest Atlantic hooded seals are considered to be data poor. Under this approach, TAC are set by considering a PBR approach. The quota has remained at 8 200 since 2007. The killing of bluebacks is prohibited in Canada.

Canadian catches of hooded seals (1+ only) have remained extremely low in recent years (Appendix 6, Table 2). Reported catches in 2006, 2007, 2008 and 2009 were only 40, 17, 5 and 10, respectively. No hooded seals were reported taken in 2010 and 2013 while 2 were taken in 2011 and 1 in 2012.

The Greenland catches of hooded seals have declined significantly in the last five years. This decrease has mainly been caused a strong decrease in catches in southeast Greenland (their molting area), where catches in 2010 and 2011 were only around 10% of the catch level from the 1990s (see the time-series in table xx, Annex 6, Table 3).

5.2.2 Current research

Canada is continuing research on diets, reproductive rates, growth and body condition and movements.

Biological parameters

No new information was presented

6 Advice for ACOM and NAFO

The chairman of WGHARP, with assistance from 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

Torger Øritsland

The working group wished to recognize the passing of a good colleague, Torger Øritsland, who died on 19 June, 2013 at the age of 83 years. For many years he was the most prominent seal scientist at the Institute of Marine Research in Norway. His prime interest was the reproductive biology of seals, in particular harps and hoods. He also worked on Antarctic seals.

Torger was instrumental in the development of WGHARP, and contributed to the cooperation between scientists from Norway, Denmark, Greenland, Canada and Russia.

After he retired (in 2000) he enjoyed life at his cabin on Sotra outside Bergen. Torger, jazz enthusiast and dedicated pipe smoker until his last days, has left us. We remember him with profound respect.

Torger Øritsland doing fieldwork in the Antarctic in 1977

Significant new information from recent harp seal surveys of the Northwest Atlantic, the White Sea and as well, a revised harp seal population model for the West Ice and White Sea harp seal populations will be available by the spring of 2014. The next meeting is tentatively scheduled for Quebec City in mid-May 2014.

8 Adoption of the report

The WG adopted the report on 30 August 2013, at the close of the meeting.

Annex 1: List of participants

Name	Address	Phone/Fax	Email
Mike Hammill (chair)	Fisheries and Oceans Canada Institut Maurice-Lamontagne P.O. Box 1000 Mont-Joli QC G5H 3Z4 Canada	Phone 1 418 775 0580	mike.hammill@dfo-mpo.gc.ca
Anne Kirstine Frie	Institute of Marine Research Institute of Marine Research Tromsø P.O. Box 6404 N-9294 Tromsø Norway	Phone 47 776 09729	anne.kirstine@imr.no
Kjell Tormod Nilsson	Institute of Marine Research Institute of Marine Research Tromsø P.O. Box 6404 N-9294 Tromsø Norway	47 776 09724	kjelltr@imr.no
Tore Haug	Institute of Marine Research Institute of Marine Research Tromsø P.O. Box 6404 N-9294 Tromsø Norway	Phone 47 776 09722	toreha@imr.no
Viktor Korzhev	PINRO Russia Knipovich stn 6 Murmansk, Russia 6 Knipovitch Street Murmansk Russia	Phone 7 815 247 2469	korgev@pinro.ru
Kornilova Svetlana	PINRO Russia Knipovich stn 6 Murmansk, Russia 6 Knipovitch Street Murmansk , Russia	+7 815 247 49 63	Korn_sv@pinro.ru
Tor Arne Øigård	Institute of Marine Research Tromsø P.O. Box 6404 N-9294 Tromsø Norway	Phone 47 776 097 14	toro@imr.no
Vlad Svetochev	Murmansk Marine Biological Institute of the Kola Science Centre of the Russian Academy of Sciences, Murmansk, Russia	+7 921 720 75 87	svol@atnet.ru
Ilias Shafikov	PINRO Russia Knipovich stn 6 Murmansk, Russia	+7 921 270 71 25	ilsi@pinro.ru
Aqqalu Rosing-Asvid	Greenland Institute of Natural Resources, Box 570, 3900 Nuuk.	Phone +299 361247	aqqalu@natur.gl

Name	Address	Phone/Fax	Email
Kirill Zharikov	VNIRO, 107140 V. Krasmoselskaya 17, Moscow, Russia	+7 916 396 49 06	zharikov@vniro.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
Timotey Mishin	PINRO, Knipovich str 6, Murmansk, Russia	+7 960 024 29 78	Mishin.tv@gmail.com
Viktor Asyutenko	PINRO, 6 Knipovitch Street RU-183763 Murmansk Russia	+7-902 133 67 68	avia@pinro.ru
Vladimir Zabavnikov	PINRO, 6 Knipovitch Street RU-183763 Murmansk Russia	Phone 7 815 247 2572	ltei@pinro.ru

Annex 2: Agenda

Monday, 26 August

10:30pm to noon –
Introductory Comments (Hammill)
Discussion of Terms of References

Stock Identity SEA 219

Noon to 1:30 pm lunch

1:30pm to 5:00pm – Harp Seals: White Sea and Barents Sea Stock
- *Information on recent catches and regulatory measures (SEA211)*
- *Current Research (SEA222,SEA223,SEA224,SEA225)*
- *Biological parameters*
- *Population assessments (SEA216)*
- Modelling and *Catch Options (SEA215,SEA216, SEA217)*

5:00pm Break for Day , *Icebreaker*

Tuesday, 27 August

9:00 am to noon – Harp Seals: White Sea and Barents Sea Stock
- *Continue Monday discussions*

Noon to 1:00pm – Lunch

1:00pm to 3:00pm-museum tour-history of PINRO

1:00pm to 5:00pm - Harp Seals: Greenland Sea Stock
- *Information on recent catches and regulatory measures (SEA211)*
- *Current Research (SEA222, SEA228)*
- *Biological parameters*
- *Population assessments (SEA212)*
- Population modelling and *Catch Options (SEA213,SEA226)*

5:00pm Break for Day

Wednesday, 28 August

9:00am to noon -- Harp Seals: Northwest Atlantic Stock
- *Information on recent catches and regulatory measures (SEA 218)*
- *Current Research (, SEA220, SEA229)*
- *Biological parameters*
- *Population assessments (SEA221)*

Noon to 1:00pm – lunch

1:00pm to 3:00pm -- Hooded Seals: Greenland Sea Stock
- *Information on recent catches and regulatory measures (SEA211)*
- *Current Research (SEA230)*
- *Biological parameters (SEA227)*
- *Population assessments (SEA213)*
- Population modelling and *Catch Options (SEA214)*

3:00pm to 3:30pm—Hooded Seals: Northwest Atlantic Stock
- *Information on recent catches and regulatory measures (SEA218)*
- *Current Research*
- *Biological parameters*
- *Population assessments*

3:30pm to 5:00pm
- R*eport writing*

5:00pm Break for Day

Thursday, 29 August

9:00am to noon
- Report writing

Noon to 1:00pm – Lunch

1:00pm to 5:00pm –
- *Review report*

5:00pm – Break for Day

Friday, 30 August

9:00 am to noon
Review/complete report

Noon to 1:00 pm lunch

1:00pm to 5:00pm –Plenary discussions
•Complete report

TOR for next meeting

- *Other business*

5:00pm – Conclude meeting

Annex 3: WGHARP terms of reference for the next meeting

The **Working Group on Harp and Hooded Seals (WGHARP)** (Chair: Mike Hammill) will meet in Quebec City, Canada for 4-5 days during May 2014 to:

a) Review results of 2012-2013 surveys of Northwest Atlantic and White Sea harp seals

b) Review development of new models to describe the dynamics of Greenland and White Sea harp seals;

c) Provide advice on other issues as requested

WGHARP will report September 2013 for the attention of the ACOM.

Annex 4: Recommendations

Recommendation	Action By
The WG recommends that efforts be made to obtain samples, particularly to evaluate reproductive rates for White Sea harp seals required for use in the population model.	Norway; as soon as possible
Taking into account the uncertainties in the trend of pup production for the White Sea population, the WG recommends that the results of the 2013 harp seal survey should be presented for review.	Russia, 2014.
The WG recommends that new aerial surveys be conducted of the White Sea\Barents Sea harp seal population in 2014	Russia, March 2014
Incorporate mortality associated with the seal invasions into the White Sea population model	Norway, As soon as possible
The WG recommends that during all aerial surveys, staging surveys also be conducted to determine the correction for pups not available to be photographed when the aerial survey is flown. This should be done for all populations of harp and hooded seals.	Norway Russia and Canada, Continuing
The Northwest Atlantic harp seal 2012 survey results and population model should be presented for review	Canada, Spring 2014
The WG recommends that satellite telemetry tagging studies be undertaken of the White Sea\Barents Sea harp seal population	Norway and Russia, Spring 2014
Given the difficulties in fitting to pup production estimates from the White Sea population, the WG recommends that different approaches to modify the model be explored to improve the fit to the data.	Norway, 2014
The WG recommended that if possible the Greenland Sea harp seal mark-recapture data be updated with new information obtained since the original analyses were completed.	Norway, 2014
The WG recommends that in the future, catch scenarios be explored over a 15 year period, rather than the current 10 years. This recommendation applies to all of the populations considered by WGHARP.	Norway, Russia and Canada, ACOM

Annex 5: References

Number	Author	Title
SEA211	Tore Haug, Tor Arne Øigård and Vladimir Zabavnikov	Norwegian and Russian catches of harp and hooded seals in the northeast Atlantic in 2012-2013
SEA212	Øigård,T.A, T. Haug, and K. T. Nilssen	Estimation of pup production of harp and hooded seals in the Greenland Sea in 2012
SEA213	Øigård,T.A, T. Haug, and K. T. Nilssen	The 2013 abundance of harp seals (Pagophilus groenlandicus) in the Greenland Sea.
SEA214	Øigård,T.A, T. Haug, and K. T. Nilssen	The 2013 abundance of hooded seals (*Cystophora cristata*) in the Greenland Sea.
SEA215	Øigård,T.A, A.K. Frie, T. Haug, and K. T. Nilssen,	The 2013 abundance of harp seals (*Pagophilus groenlandicus*) in the Barents sea / White sea
SEA216	Shafikov, I., S.Egorov	Airborne surveys for whelping patches of the White Sea harp seal population (15-21 March 2013)
SEA217	Shafikov, I.,	Estimation of the harp seal White Sea population according to the data from the assessment of the pup production and female fecundity
SEA218	Stenson, G.	Recent Catches and Quotas of Harp and Hooded Seals in Canada
SEA219	Carr, S.M., A.T . Duggan, G.B. Stenson, and HD Marshall	Whole-mitogenome variation among harp seals (*Pagophilus groenlandicus*): quantitative analysis of phylogeographic structure among discrete transatlantic breeding areas
SEA 220	Perry, E.A., G. B. Stenson and A. D. Buren	Parental care strategy of capital breeding harp seals: Coping with thermoregulation during lactation
SEA 221	Stenson, G.B., M.O. Hammill, J.W. Lawson, J-F Gosselin	Estimating Pup Production of Northwest Atlantic Harp Seals, Pagophilus groenlandicus: Preliminary Results of the 2012 Surveys:Southern Gulf of St Lawrence
SEA 222	McKinney, M. A. , S. J. Iverson, A. T . Fisk, C. Sonne, F. F. Riget, R. J. Letcher, M.T . Arts, E. W. Born, A. Rosing-Asvid and R. Dietz	Global change effects on the long-term feeding ecology and contaminant exposures of East Greenland polar bears. Global Change Biology (2013), doi: 10.1111/gcb.12241
SEA 223	Grahl-Nielsen, O, T. Haug, U. Lindstrøm, K. T. Nilssen.	Fatty acids in harp seal blubber do not necessarily reflect their diet.Mar. Ecol. Prog. Ser. Vol. 426: 263–276
SEA224	Lindstrøm,U., K. T. Nilssen, L. M. S. Pettersen and T. Haug	Harp seal foraging behaviour during summer around Svalbard in the northern Barents Sea: diet composition and the selection of prey. Polar Biol (2013) 36:305–320

SEA225	Øigård, T.A., U. Lindstrø1, T. Haug, K. T. Nilssen1, and S. Smout	Functional relationship between harp seal body condition and available prey in the Barents Sea. Mar Ecol Prog Ser. Vol. 484: 287–301
SEA226	Øigård, T.A., Haug, T. and Nilssen, K.T.	From pup production to quotas: Current status of Harp Seals in the Greenland Sea.
SEA227	A.K. Frie	Ovary based pregnancy rates of Greenland Sea hooded seals (Cystophora cristata) 1958-1999
SEA228	Foote AD, Newton J,Avila-Arcos MC, Kampmann M-L, Samaniego JA, Post K, Rosing-Asvid A, Sinding M-HS, Gilbert MTP.	Tracking niche variation over millennial timescales in sympatric killer whale lineages. Proc R Soc B 280: 20131481. http://dx.doi.org/10.1098/rspb.2013.1481
SEA229	Stenson,G., L. Richards, O. Nielsen and L. Measures	Unusual Mortality of Harp Seals in Newfoundland during 2010/11
SEA230	Nymo, I.H., M. Tryland, A. K. Frie , T. Haug, G.Foster, R. Rødven, J. Godfroid	Age-dependent prevalence of anti-Brucella antibodies in hooded seals (*Cystophora cristata*). In press
SEA 231	Frie, A.K.,G. B. Stenson, and Tore Haug	Long-term trends in reproductive and demographic parameters of female Northwest Atlantic hooded seals (Cystophora cristata): population responses to ecosystem change? Can. J. Zool. 90: 376–392.

Other References

Author	Year	Citation
Fournier, D. A., Skaug, H. J., Ancheta, J., Ianelli, J., Magnusson, A., Maunder, M. N., Nielsen, A.	2012	AD Model Builder: using automatic differentiation for statistical inference of highly parameterized complex nonlinear models. Optimization Methods and Software, 27: 233–249.
Frie, A.K.	2013	Ovary based pregnancy rates of Greenland Sehooded seals (Cystophora cristata) 1958-1999. WGHARP WP SEA 227.
Frie, A.K., Potelov, V.A., Kingsley, M..C.S. & Haug, T.	2003	Trends in age at maturity and growth parameters of female northeast Atlantic harp seals, *Pagophilus groenlandicus* (Erxleben, 1777). ICES J. mar. Sci. 60: 1018-1032.
Frie A.K.	2008	An update on reproductive parameters of Greenland Sea harp seals Pagophilus groenlandicus. Frie A.K. Joint ICES/NAFO Working Group on Harp and Hooded Seals. 2008. Working Doc. 18, 11 pp.
Gaydenok N.D, Makarevich, P.R., Ognetov, G.N. and Chmarkova G.M.	2012.	Analysis of monitoring results for the White Sea harp seal population [in Russian]. Rybnoe Khozjaistvo 26, 14 pp.

Gelman, A., Carlin, J. B., Stern, H. S., and Rubin, D. B.	1995	Bayesian Data Analysis. Chapman and Hall, London. 526 pp.
Hammill, M.O. and G.B. Stenson.	2007.	Application of the Precautionary Approach and Conservation Reference Points to the management of Atlantic seals. ICES Journal of Marine Science, 64: 702–706.
Hammill, M. O. and Stenson, G. B.	2009	A preliminary evaluation of the performance of the Canadian management approach for harp seals using simulation studies. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/093. iv + 47 p.
Hammill, M.O. and Stenson, G.B.	2010	Abundance of Northwest Atlantic harp seals (1952-2010). DFO CSAS Res. Doc. 2009/114: 12 pp
Haug, T., Krøyer, A.B., Nilssen, K.T., Ugland, K.I. & Aspholm, P.E.	1991	Harp seal (Phoca groenlandica) invasions in Norwegian coastal waters: age composition and feeding habits. ICES J. Mar. Sci. 48: 363-371.
Haug, T., Øigård, T.A., Zabavnikov, V.	2013	Norwegian and Russian catches of harp and hooded seals in the Northeast Atlantic in 2012 and 2013. WGHARP WP SEA 211.
Haug, T., Stenson, G.B., Corkeron, P.J., and Nilssen, K.T	2006	Estimation of harp seal (Pagophilus groenlandicus) pup production in the North Atlantic completed: Results from surveyws in the Greenland sea in 2002. ICES Journal of Marine Science, 63: 95-104.
ICES	2005	Report of the Joint ICES/NAFO Working Group on Harp and Hooded Seals (WGHARP), St. John's, Newfoundland, Canada, 30 August - 3 September 2005
ICES	2006	Report of the Joint ICES/NAFO Working Group on Harp and Hooded Seals, 30 August-3 September 2005St John's Newfoundland, Canada. ICES CM 2006/ACFM 17. 46 pp.
ICES	2008	Report of the Joint ICES/NAFO Working Group on Harp and Hooded Seals, 30 August-3 September 2009, ICES Headquarters. ICES CM 2009/ACOM 17. 51 pp.
ICES	2009	Report of the Joint ICES/NAFO Working Group on Harp and Hooded Seals, 24-27 August 2009, ICES Headquarters. ICES CM 2009/ACOM 17. 51 pp.
ICES	2011	Report of the Joint ICES/NAFO Working Group on Harp and Hooded Seals, 15-19 August 2011, St. Andrews, Scotland, UK. ICES CM 2011/ACOM:22. 64 pp.
Kjellquist, S.A., Haug, T. and Øristland, T.,	1995	Trends in age composition, growth and reproductive parameters of the Barents Sea harp seals Phoca groenlandica ICES Mar.Sci., Vol.52, pp.197-208).
Khuzin, R.	1972	Ecological and morphological analysis of differences and prospects of hunting harp seals from the White Sea, Jan-Mayen and Newfoundland populations. Murmank, Murmansk Press, 1972, 174 p. (in Russian)
Lukin, L.R.	2005	Ecology of the North Atlantic pagethod seals in reproductive period. Author abstract for Phd Thesis, Arkhangelsk, 2005, 50 pp. (in Russian)
Popov, L.A.	1966	Na l'dine s tjulenjami (On ice with the seals). Priroda 9: 93-101. (In Russian)

Potelov, V.A., Golikov, A.P. and Bondarev, V.A.	2003	Estimated pup production of harp seals (Pagophilus groenlandicus) in the White Sea, Russia, in 2000. ICES J. Mar. Sci. 60: 1012-1017.
Salberg, A.B., T. Haug and K.T. Nilssen.	2008	Estimation of hooded seal (Cystophora cristata) pup production in the Greenland Sea pack ice during the 2005 whelping season. Polar Biol., 31 : 867-878.
Shafikov I.N.	2009	The White/Barents seas harp seal (Phoca groenlandica) population express asseement on data of breeding accounting //Joint ICES/NAFO Working Group on Harp and Hooded Seals, Copenhagen, Denmark, 24-28 August 2009
Sjare, B., G.B. Stenson.	2010	Changes in the reproductive parameters of female harp seals Pagophilus groenlandicus in the Northwest Atlantic. ICES J.Mar.Sci., Vol. 67, pp. 304-315.
Skaug, H.J., Frimannslund, L. and Øien, N.I	2007	Historical population assessment of Barents Sea harp seals (Pagophilus groenlandicus). ICES J. Mar. Sci., 64:1356-1365.
Stenson, G. B., M. O. Hammill, and J. Lawson.	2010	How many harp seal pups are there? Additional results from the 2008 surveys. Canadian Science Advisory Secretariat Research Document 2010/137
Stenson, G. B. and M. O. Hammill	2010	Improving the Management of Atlantic Seals under the Precautionary Approach. Canadian Science Advisory Secretariat Research Document 2010/135
Stenson, G.B., and Wells, N.J.	2011	Current reproductive and maturity rates of Northwest Atlantic harp seals, (Pagophilus groenlandicus). DFO Can. Sci. Advis. Sec. Res. Doc. 2010/136 iv + 13 p.
Stirling, I.	2005	Reproductive rates of ringed seals and survival of pups in northwestern Hudson Bay, Canada, 1991–2000. Polar Biology, 28: 381–387.
Timoshenko, Y.K.	1995	Harp seals as indicators of the Barents Sea ecosystem. Whales, seals, fish and man. Development in marine biology. 1995. Vol.4. pp.509-523
Øien, N. and Øritsland, T.	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.
Øigård, T.A., Haug, T. and Nilssen, K.T.	2013	From pup production to quotas: Current status of Harp Seals in the Greenland Sea. ICES Journal of Marine Science. In press.
Øigård, T.A., Haug, T. and Nilssen, K.T	2013	Estimation of pup production of hooded and harp seals in the Greenland Sea 2012. WGHARP WP SEA 212, 26. – 30. August, Murmansk, Russia.
Øien, N. and Øritsland, T	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.
Øigård, T.A., Haug, T., Nilssen, K.T. and Salberg, A.-B.	2010	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. Vol. 42 pp. 103 - 123.
Øigård, T.A.,, Lindstrom U., Nilssen, K. T., and Haug, T.	2011	Anon., 2011. Variations in body condition of Barents Sea harp seals during April – May in 1992 – 2011. //Joint ICES/NAFO Working Group on Harp and Hooded Seals, St. Andrews, UK, 15-19 August 2011, SEA196

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 2013[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
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

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
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
2010	14	164	178	-	-	-	14	164	178
2011	15	4	19	-	-	-	15	4	19
2012	15	6	21	-	-	-	15	6	21
2013	15	7	22	-	-	-	15	7	22

[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"), 1946-2013a,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				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
1971-75	6550	5247	0	11797	92	56	0	148	6642	5303	0	11945
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	393d	0	56	0	56	206	243	0	449
1985	215	220	0	435d	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	94d	0	0	636[e]	636	41	53	636	730
1991	0	14	0	14d	0	0	6411[e]	6411	0	14	6411	6425
1992	35	60	0	95d	0	0	119[e]	119	35	60	119	214
1993	0	19	0	19d	0	0	19[e]	19	0	19	19	38
1994	19	53	0	72d	0	0	149[e]	149	19	53	149	221
1995	0	0	0	0	0	0	857[e]	857	0	0	857e	857
1996	0	0	0	0	0	0	25754[e]	25754	0	22847f	2907	25754
1997[e]	0	0	0	0	0	7058	0	7058	0	7058	0	7058
1998[e]	0	0	0	0	0	10148	0	10148	0	10148	0	10148
1999 [e]	0	0	0	0	0	201	0	201	0	201	0	201
2000 [e]	2	2	0	4[d]	0	10	0	10	2	12	0	14
2001[e]	0	0	0	0	0	140	0	140	0	140	0	140
2002 [e]	0	0	0	0	0	150	0	150	0	150	0	150
2003 [e]	0	0	0	0	0	151	0	151	0	151	0	151
2004 [e]	0	0	0	0	0	389	0	389	0	389	0	389
2005 [e]	0	0	0	0	0	20	0	20	0	20	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	10	0	10	0	10	0	10
2010[e]	0	0	0	0	0	0	0	0	0	0	0	0
2011[e]	0	0	0	0	0	2	0	2	0	2	0	2
2012[e]	0	0	0	0	0	1	0	1	0	1	0	1
2013[e]	0	0	0	0	0	0	0	0	0	0	0	0

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

[b] All values prior to 1990 are from NAFO except where noted; recent years are from Stenson (2009) and DFO Statistics Branch.

[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 based upon seizures of illegal catches

Table 3. Catches of hooded seals in West and East Greenland 1954–2008 .

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
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	2575	-	712	3287	7	3294
2008	2085	-	519	2604	2	2606
2009	**1627**	-	358	1982	1	**1986**
2010	**1871**		**266**	**2137**	**7**	**2144**
2011	**1827**		**225**	**2052**	**9**	**2061**

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 2013[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
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
2010	2823	1855	4678	-	-	-	2823	1855	4678
2011	5361	4773	10134	-	-	-	5361	4773	10134
2012	3740	1853	5593	-	-	-	3740	1853	5593
2013	13911	2122	16033	-	-	-	13911	2122	16033

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"), 1946–2011[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
2010	0	105	105	5	5	10	5	110	115
2011	0	200	200	0	0	0	0	200	200
2012	-	-	-	0	9	9	0	9	9
2013	-	-	-	-	-	-	-	-	-

[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 1952-2011. Estimated catches are indicated by shading. The Greenland catches are made up of the Table 5 West Greenland catches and 1/2 of the SE Greenland. The other half of the SE Greenland and the NE Greenland are assigned to the West Ice population.

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

Year	Front & Gulf	Canadian Arctic	Greenland	NW Atlantic Total
2000	92,055	400[a]	99,801	192,256
2001	226,493	600[a]	86,763	313,856
2002	312,367	1,000	67,725	381,092
2003	289,512	1,000	67,607	358,119
2004	365,971	1,000	72,105	439,076
2005	323,826	1,000	93,121	417,947
2006	354,867	1,000	93,318	449,185
2007	224,745	1,000	84,272	310,017
2008	217,850	1,000	82,414	301,264
2009	76,668	1,000	71,716	149,384
2010	69,101	1,000	91,018	161,119
2011	40389	1,000	74,823	116,212
2012	71460	1,000	80,849[b]	153,309
2013	90703	1,000	80,849[b]	172,552

[a] Rounded
[b] Average of catches 2007-2011

Table 4. Reported Canadian catches of Harp seals off Newfoundland and in the Gulf of St. Lawrence, Canada ("Gulf" and "Front"), 1946–2011a,b. Catches from 1995 onward include catches under the personal use licences. YOY = Young of Year.

	Large Vessel Catch				Landsmen Catch				Total Catches			
Year	YOY	1+	Unk	Total	YOY	1+	Unk	Total	YOY	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
1971-75	106425	12778	0	119203	29813	12320	0	42133	136237	25098	0	161336
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
1981d	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	644e	23827	7073	0	30900	23922	7622	0	31544
1985	0	1	0	1e	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	232e	56345	5691	3036	65072	56346	8958	0	65304
1990	48	74	0	122e	34354	23725	1961	60040	34402	25760	0	60162
1991	3	20	0	23e	42379	5746	4440	52565	42382	10206	0	52588
1992	99	846	0	945e	43767	21520	2436	67723	43866	24802	0	68668
1993	8	111	0	119e	16393	9714	777	26884	16401	10602	0	27003
1994	43	152	0	195e	25180	34939	1065	61184	25223	36156	0	61379
1995	21	355	0	376e	33615	31306	470	65391	34106	31661	0	65767
1996	3	186	0	189e	184853	57864	0	242717	184856	58050	0	242906
1997	0	6	0	6e	220476	43728	0	264204	220476	43734	0	264210
1998	7	547	0	554e	0	0	282070	282070	7	547	282070	282624
1999	26	25	0	51e	221001	6769	16782	244552	221027	6794	16782	244603
2000	16	450	0	466e	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	0	0	0	0	319127	4699	0	323826	319127	4699	0	323826
2006	0	0	0	0	346426	8441	0	354867	346426	8441	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	76668	0	0	76668	76668	0	0	76668
2010	0	0	0	0	68654	447	0	69101	68654	447	0	69101
2011	0	0	0	0	40371	18	0	40371	40371	18	0	40371
2012	0	0	0	0	71319	141	0	71460	71319	141	0	71460
2013	0	0	0	0	90703	0	0	90703	90703	0	0	90703

a For the period 1946-1975 only 5-years averages are given.

b All values prior to 1990 are from NAFO except where noted, recent data from Stenson (2009) and DFO Statistics Branch.

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 1993–2009 (Piniarneq), and % adults according to the hunters' reports .

Year	West Greenland		South East Greenland		North East Greenland		All
	Catch	%	Catch	%	Catch	%	Catch
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]
1988-1992	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	81,485	32	2,702	21	85	53	84,272
2008	78,747	32	3,617	15	50	90	82,414
2009	**70 869**	**32**	**2 546**	**9**	**83**	**75**	**73 498**
2010	**89 045**	**25**	**1 938**	**12**	**35**	**34**	**91 018**
2011	**73 277**	**30**	**1 472**	**16**	**74**	**26**	**74 823**

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 1952-2013.

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	1,092	47,991	227,825
1977	169,793	1,577	44,094	215,464
1978	180,490	2,919	65,474	248,883
1979	181,706	3,310	50,585	235,601
1980	191,131	2,717	60,048	253,896
1981	229,815	3,921	53,222	286,958
1982	198,547	3,785	54,740	257,071
1983	87,555	4,962	40,131	132,648
1984	62,254	4,108	39,591	105,952
1985	44,701	4,857	32,069	81,627
1986	56,914	8,178	36,178	101,269
1987	89,536	13,096	55,099	157,731
1988	139,342	8,545	75,895	223,781
1989	113,156	10,256	59,775	183,187
1990	110,569	3,621	77,978	192,168
1991	105,551	9,689	65,400	180,640
1992	124,187	25,476	82,629	232,292
1993	88,203	26,472	72,665	187,340
1994	125,944	47,255	102,049	275,248
1995	136,946	20,395	104,635	261,975
1996	321,734	29,201	146,607	497,542
1997	335,526	18,869	126,654	481,048
1998	364,896	4,641	126,725	496,262
1999	338,169	16,111	113,033	467,313
2000	190,914	11,347	110,354	312,615
2001	312,521	19,475	109,069	441,065
2002	380,102	9,329	98,009	487, 440
2003	356,661	5,367	91,233	453, 261
2004	437,557	12, 593 a	102,612	552 ,761
2005	416,522	12, 325 a	115, 767	550, 616
2006	448,077	12, 355 a	119, 884	580, 316
2007	308,581	12, 447 a	98, 750	419, 778
2008	299,406	12, 704 a	93 ,292	405, 402
2009	149,810.00	12, 775 a	77, 177	239, 762

Year	Reported	Bycatch	Struck and Lost	Total
2010	160,115.00	12, 575 a	95, 074	267, 764
2011	115,402.00	12,571 a	77 ,156	205, 129
2012	151,153.55	12,571 a	83, 588	247, 313
2013	170,396.55	12,571 a	84, 467	267, 435

[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"), 1985–2013.

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	
2007-13[14]			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
2010	10 April	31 May	42,000				42,000	0
2011	10 April	31 May	42,000				42,000	0
2012-13	10 April	31 May	25,000				25,000	

[1] Other regulations include: Prescriptions for date for departure Norwegian port; only one trip per season; licensing; killing methods; and inspection.

[2] Basis for allocation of USSR quota.

[3] Breeding females protected ; two pups deducted from quota for each female taken for safety reasons.

[4] Adult males only.

[5] 1 year+ seals protected until 9 April; pup quota may be filled by 1 year+ after 10 April.

[6] Any age or sex group.

[7] Included 750 weaned pups under permit for scientific purposes.

[8] Pups allowed to be taken from 26 March to 5 May.

[9] Half the quota could be taken as weaned pups, where two pups equalled one 1+ animal.

[10] The whole quota could be taken as weaned pups, where two pups equalled one 1+ animal.

[11] Russian allocation reverted to Norway.

[12] Quota given in 1+ animals, parts of or the whole quota could be taken as weaned pups, where 1,5 pups equalled one 1+ animal.

[13] Quota given in 1+ animals, parts of or the whole quota could be taken as weaned pups, where 2 pups equalled one 1+ animal.

[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"), 1979–2013.[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
2010				7,000	0	7,000
2011				7,000	0	7,000
2012-13				15,287	0	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, 1961–2013.

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
2010	TAC increased to 330,000
2011-2013	TAC increased to 400,000

Table 4. Major management measures implemented for hooded seals in Canadian waters for 1964–2013.

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. Number of adult females limited 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
2009-2013	Additional requirements implemented to ensure humane killing methods are used

Annex 9 – Review of ICES WGHARP REPORT 2013

Reviewer 1 (DT)

Overall the report gives a clear, consistent and comprehensive assessment of the status of the various harp and hooded seal stocks using all the relevant, available information. The WG have provided detailed descriptions of the survey methods and population models and have provided well-argued justifications for the methods used. They have identified several weaknesses in the data due to gaps in the survey coverage and the temporal patterns of pup production estimates, problems interpreting older mark recapture data and the absence of useful demographic parameter estimates in some cases.

The table of recommendations seems to address all of these issues, calling for additional work where required. It is not clear to me where the recommendation for satellite telemetry studies came from, but I think it sounds like an interesting project.

I do not see any major problems with any of the recommended harvest levels. In each case the recommended level is based on the best estimate and a range of alternative strategies is presented. Where appropriate a conservative or precautionary approach is recommended.

However, in both the White Sea and the Greenland Sea model runs (figs 4 & 6) the pup production trajectories have very tight confidence intervals and clearly miss a substantial proportion of the pup survey estimates (for 50% of the White sea estimates the lower 95% c.i. is above the upper 95% ci of the predicted line, for the Greenland Sea the same is true for 30% of the survey estimates).

This probably indicates that the models are not effectively dealing with fluctuations in fecundity. Does this indicate that the confidence intervals of the model predictions are unrealistically tight? If it does, then does that also imply that the predictions of the effects of different harvest strategies are also unrealistically precise?

In terms of general presentation my only recommendation would be to alter the emphasis of the population estimation section of part 4.2 to reflect the concerns described above. At present there is an extensive and detailed description of the model structure and a description of the results including comparisons between the model outputs and target population levels. However, the model clearly does not fit to the recent pup production estimates. It is only at the end of the section that the authors report the problems with the model and then indicate that they are not confident that the outputs are robust enough or accurate enough to provide management advice. They go as far as recommending alternative modelling approaches.

I recognise that the absence of any substantial hunt of this stock means that the modelling difficulties will not lead to any major over exploitation problems but I think that the WG's legitimate concerns should be highlighted at an earlier stage, preferably where the model output is presented and described in the results section. If the lack of fit to the pup production data means that the model output is not trusted then it seems strange to use it to predict the consequences of different harvest regimes.

Specific points.

Page 4 onwards. I think that the use of the phrase "barrenness factor" is strange. In general people use either fecundity or pregnancy rate for this.

Page 5. I am not sure that the equation relating population size to barrenness and age specific maturity is providing useable information in the absence of age specific survival rates. The report goes on (page 6) to provide population estimates of 1.3 -2.1 million whereas figure 1 shows a range of values from 1 to 4.5 million. It might be better to just state the well-known fact that fecundity values are effectively a simple ratio between pup production and adult female population size.

Page 6. The pup survival rates for favourable, unfavourable and very unfavourable all seem very high. Are the mortality rates annual rates and if so are the resulting survival rates of 0.7 realistic for years with "very unfavourable" conditions?

Page 6 I am unclear what the section "*Incorporating smoothed reproductive data from the Northwest Atlantic harp seal population which included a decline in fecundity improved the fit to the survey data*." actually means. I think it needs another sentence to explain how these fecundity estimates from a different region/stock were incorporated into the model.

Page 6. The statement that the PBR estimates were not sustainable needs some explanation. PBR is designed to be sustainable and to effectively guide a population towards its optimal productivity level. That target level may be lower than the current value if the population is near carrying capacity, but it should still produce a stable, sustainable harvest value.

In two cases (page 9 and page 17) the model priors are described as "normal priors", while this may be true for the N_{t0} prior it can't be true for the mortality rate priors must lie between 0 and 1.

Page 9, model results…see general comment above.

Page 11. Sentence starting "Gaydenock et al……" does not make grammatical sense.

Page 12. Is the population estimate given as the mean of a log normal? The PBR calculation just uses the lower 20^{th} percentile of the population estimate.

Page 14. figure 4 should be moved forward to page 10.

Page 17. The WG recommend that the mark recapture data be updated with new information. Would it be possible to provide some indication of what this new analysis/re-analysis of the historical mark recapture data would entail?

Reviewer 2 (RK)

I commend the authors on the thorough report completed in such a short time. Overall, the report was easy to read and logical and the science was strong, or explained well where there were weaknesses. My experience with harp and hooded seal management is less than that of any member of the working group. In acknowledging their experience and expertise, I do not pretend to offer a greater 'expert' opinion on the report. I confine my comments/ suggestions to several points which stood out to me and could require further explanation for the less experienced audience.

Harp seals

Call for updated figure for White sea pup production

White Sea	Year	Pups	Catch	Population
	2000		40000	
	2001	330000	40000	
	2002	330000	35000	
	2003	330000	40000	
	2004	230000	0	
	2005	122000	15000	
	2006		7000	
	2007		5000	
	2008	123000	13000	
	2009	157000	0	
	2010	163000	0	
no data	2011		0	
no data	2012		0	
no data	2013	200000	0	1.4M

The data summarised in the table above, was used to provide the estimate of 200,000 pups for 2013. The figure relies on an increasing trend, which is not strongly evident in the data. I agree with the working group's call for an updated pup production figure.

Suggested harvest rates

Harvest	Seals	N in 10 years	Rationale
17000	adults	231000	ie bring to N70 of 330000
40000	pups	168000	ie reduce 16% in 10 years (=N50)

I am not sure how precautionary the proposed harvest rates are? For instance, catches of 40000 pups per year (as occurred prior to 2003), particularly in conjunction with other factors (such as what happened in 2004), could reduce population to less than the 16% estimated for the 10 year period.

The harvest rates presented appear to be 'guides', rather than more exact ranges, which I feel the group has the data to give. Perhaps this is deliberate?

Barren females (page 5)

Barren suggests to me the ovaries are not productive and the female will never pup again, when I suspect the term is used to suggest not pregnant that season. This is perhaps a translation issue. I am not convinced that the reversal of the normal 'pregnancy rate', to provide a 'non-pregnancy' rate opens new avenues for interpretation?

Modelled data

Figures 4 and 6 model population size based on pup productions (along with pregnancy rates etc). However, the models do not fit the actual data at all? This may need to be explained, because at present the models look unconvincing. In figure 4, the profound and sustained halving of pup numbers sits on a steady line of modelled pup production that has very tight confidence intervals, and is reflected by an in-

creasing trend in total population. In figure 6, the variable but 'no clear trend' in pup estimates is set against a model for slightly increasing numbers, again with exceedingly tight confidence intervals, and a doubling of total population.

Northwest Atlantic Stock

NW Atlantic	Year	Canada	NW Atlan	Removal
	2000	85000	190000	310000
	2001	215000	314000	440000
	2002	300000	381000	490000
	2003	280000	358000	450000
	2004	350000	439000	550000
	2005	320000	417000	550000
	2006	350000	449000	580000
	2007	220000	310000	420000
	2008	217000	301000	400000
	2009	76000	149000	240000
	2010	68000	161000	270000
	2011	40000	116000	200000
	2012	71000	153000	250000
	2013	90000	172000	270000

Data presented in the text seem focussed on the Canadian commercial hunt. Total NW Atlantic figures and total removal estimates are provided in appendices, and appear to reveal some different trends. Considering the importance of these harvests, more could be expressed in the text and in the Executive summary. The impact of reduced ice in 2007 is profound. More so is the drop in 2009 but reasons for this are not provided? I imagine this was further reduction in ice. The doubling in take between 2011 and 2013 suggests an improvement in ice conditions, but I am not sure this is the case?

Reviewer 3 (SM)

Harp seals

Section 4.2 White Sea and Barents Sea Stock

This population is considered data poor, primarily due to a lack of recent data on reproductive rates.

For this population the WG reported a decline in harp seal pup production since 2004, and a decline in body condition of seals since 2001 (to a minimum in 2011) that may have had implications on breeding success. A decline in body condition may have been caused by competition between harp seals and other species for shared resources such as krill. The WG reported that total population size was very sensitive to changes in the barrenness factor (i.e. non reproductive/pregnant females - not sure about using the word "barren" as it sometimes infers sterility which is not the case in this study) and average age at maturity.

An age structure population dynamics model reported an abundance of 1 221 000 (1 069 800 – 1 372 200) 1+ animals and 198 800 (177 483 – 220 117) pups. The total esti-

mated population is 1 419 800 (1 266 910 – 1 572 690) for 2013. Experts within the WG would be better versed at commenting on the effectiveness of the model used, and they reported that the model was very stiff, and the fit to the observed pup production estimates was poor. This was mainly due to a lack of historical data on pregnancy rates. Pup production data suggests that fecundity may be lower than the assumed rate of 64%. In addition, earlier surveys (prior to 1998) were not corrected for errors such as proportion of females on the ice (as this will vary with time of day), temperature, wind speed etc. Pup production estimates obtained between 1998and 2004 were over estimates, presumable due to errors in the surveys and/or in the subsequent analysis.

I agree with using the equilibrium catch level of 17400 (100% 1+) seals, as this population is data deficient, this is the more conservative option. In 2011 and 2012 only nine seals were taken for subsistence use, and no other seals were caught by hunters.

I agree with the recommendations of the WG:

- The WG **r**ecommends that efforts be made to obtain samples, particularly to evaluate reproductive rates for White Sea harp seals required for use in the population model.
- Taking into account the uncertainties in the trend of pup production for the White Sea population, the WG recommends that the results of the 2013 harp seal survey should be presented for review.
- the seal invasions into thethe White Sea population model.
- thethe fit to the data

Section 4.3 Greenland Sea Stock

This population is considered data rich, and above the N_{70} level. Removals represented 22% and 53% of the identified sustainable levels in 2012 and 2013.

Total population abundance is 627, 410 harp seals. As noted by the WG, the model had difficulty in capturing the dynamics of the pup production estimates, possibly due to the mark-recapture estimates of pup production from the 1980s and 1990s – there are uncertainties around these estimates.

I agree with the recommendations from the WG

The WG recommended that if possible the Greenland Sea harp seal mark-recapture data be updated with new information obtained since the original analyses were completed.

Section 4.4 Northwest Atlantic Stock

Catches for Canada in 2013 were 22.7% of the TAC quota (90,073 harp seals). Since2008, 99% of the reported catch was young of the year. The TAC is set at 400,000 harp seals for 2011, 2012 and 2013. No information was provided on regulations for Greenland. The WG noted that "catches of harp seals in Southeast Greenland, which are a mixture of seals from the west Atlantic and the Greenland Sea populations, has been declining in recent years". Looking at Table 5 in Annex 7, catches are declining since a peak of 3,617 seals in 2008.

No information on population abundance was provided in the report. A survey of the Northwest Atlantic population was undertaken during March 2012, but final estimates were not available. A preliminary estimate of pup production for the southern Gulf of St Lawrence was 114,900 (SE=15,000) animals, significantly lower than the

number of pups estimated in 2004 and 2008. Ice conditions in 2012 were among the worst on record, similar to those in 2010 and 2011 The WG noted that if these conditions continue this would have serious implications for the persistence of harp seals in the southern Gulf of St Lawrence. Although ice conditions were poor in both years, numbers of seals caught increase from 40,389 in 2011 to 71,460 in 2012. No further information was provided. A significant drop in numbers caught was reported in 2009, and I am assuming this was during the period there was almost no ice in the Gulf (winter 2009/10).

Unusual morality event observed among harp seals in the Newfoundland area in the winter of 2010/2011 and spring of 2011. As yet, all attempts at identifying the cause of these deaths have been unsuccessful and no viruses have been isolated. The WG noted that a significant number of seals may have died during this event.

The WG noted that the interannual variability in fecundity was in response to changes in late term abortions, influenced by changes in capelin (their main prey). What stage of gestation do the WG designate as late term?

I agree with the recommendations from the WG

The Northwest Atlantic harp seal 2012 survey results and population model should be presented for review.

Hooded Seals

Section 5.1 – Greenland Sea stock

I agree with the WG that following the precautionary harvest strategy no catches should be taken from this population.

Section 5.2 –NW Atlantic stock

Missing Hammill and Stenson (2007; 2009b) references.

As the NW Atlantic stock is data deficient, are surveys being planned to assess pup production of the NW Atlantic stock in the near future? From what I can see on the DFO website the last survey to determine pup production in the Gulf of St Lawrence, at the Front and in Davis Strait was completed in 2005.

Why has there been a strong decrease in catches in southeast Greenland in recent years?