ICES WGHARP REPORT 2011

ICES ADVISORY COMMITTEE

ICES CM 2011/ACOM:20

REF: NAFO SCIENTIFIC COUNCIL

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

15 – 19 August 2011

St. Andrews, Scotland, UK

International Council for the Exploration of the Sea

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. 2011. Report of the Working Group on Harp and Hooded Seals (WGHARP), 15 - 19 August 2011, St. Andrews, Scotland, UK. ICES CM 2011/ACOM:20. 68 pp.

Contents

Executive Summary

The ICES/NAFO Working Group on Harp and Hooded Seals (WGHARP) met during 15-19 August 2011 at the British Sea Mammal Research Unit (SMRU) at the Scottish Oceanographic Institute, University of St. Andrews, Scotland. The WG received presentations related to 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 September 2010 request from Norway. The WG also responded to a request from NAFO to consider the impacts of the increasing northwest Atlantic harp seals on the number of seals near Greenland. The WG then acted on requests from the ICES Directorate and the EU to consider issues related to Ecosystem Based Management and Marine Spatial Planning. The WG concluded their meeting on 19 August. In attendance were scientists representing Canada (2), Greenland (1), Norway (3), Russia (2), and United States (1)(Annex 1), as well as the SMRU (3).

A survey of the White Sea/Barents Sea harp seal stock during 20-23 March 2010, and resulted in an estimate of 163,032 pups (SE = 33,342). The WG agreed that the survey appeared to have been carried out very well. The WG discussed several hypotheses to explain the reduced pup production since 2004 including unobserved mortality of adults ca. 2004, high mortality of neonates prior to the aerial surveys, or declines in fecundity (i.e. pup production). The most parsimonious explanation for the continued low count of pups in surveys in both good and bad ice years appears to be a decline in fecundity given the lack of evidence for a significant adult mortality event. This is significant because fecundity can be explored as part of the population modelling effort. The existing NE model could not account for the precipitous decline in pup production after 2003 with a fixed fecundity and maturity. Because of this, the NE model was considered inappropriate to provide catch options (as in the WG's 2009 meeting). A revised NE model with time-varying maturity and condition varying fecundity (i.e., as animal conditions improves, fecundity improves) provided a good fit to the observed pup counts. However, this model was considered <u>preliminary</u> and not ready at this time to be applied. A <u>modified</u> version of the existing NE model with time-varying maturity and fecundity provided a transitional model form, and was considered to be an appropriate temporary analytic tool. This model provided a 2011 population estimate of 1,364,700 total animals (SE = 68,503). Using this approach, the WG estimated that the sustainable catch for the White Sea/Barents Sea harp seal stock should be 26,535 seals (including 19,795 pups and 6,740 1+ animals) or 15,827 1+animals (with no harvest of pups).

With respect to the Greenland Sea harp seal stock, no new data have been collected since 2009, but the recent series of catch and reproductive data leads the WG to still consider the stock to be data rich with abundance greater than N_{70}. Therefore, it is appropriate to use a population model to estimate abundance and evaluate catch options. All model runs seem to indicate a substantial increase in the population abundance from the 1970s to the present. All model predictions indicate an increase in the abundance of 1+ animals on a 10 year scale, ranging from an increase of 31% - 49%, assuming no hunt. Using the NE model with time varying reproductive parameters, a 2011 abundance of 553,100 1+ animals and 96,470 pups are obtained. A 95% confidence interval for the 1+ population is (286,480 – 819,720). Total 2011 abundance of harp seals in the Greenland Sea is estimated to be 649,570 (379,031 – 920,101). The estimate provided by the modified model is lower than estimates provided by the

original NE model. Based on the modified model's results, the WG suggests that sustainable catches are 25,410 animals (of which 63.4% are pups) or 16,737 (100% 1+ animals). An annual catch level of 35,000 (assuming 63.4% pups) or 25,000 (assuming 100% 1+ animals) would reduce the population to 70% of current level with 80% probability over a 10-year period.

The March-April 2007 Norwegian survey of hooded seal pup production in the Greenland Sea produced an estimate of 16,140 pups (SE = 2,140). This estimate is not significantly different from the estimate obtained with comparable methodology in the Greenland Sea in 2005, but is considerably lower than the 1997 estimate. The model developed for the 2011 assessment is similar to the model assessing the abundance of the Barents Sea / White Sea harp seal population, modified to incorporate historical maturity curves and historical pregnancy rates. The available historical data on pregnancy rates were considered unreliable. Hence, the model was run for a range of pregnancy rates, in addition to a run using the original model assuming constant reproductive data. All model runs indicate a population currently well below N_{30} (30% of largest observed population size). Following the Precautionary harvest strategy previously developed by WGHARP, catches should not occur for populations below N_{30}. Therefore, WGHARP suggests no catches are sustainable from the Greenland Sea hooded seal stock.

Historically the abundance of seals in Greenland waters was positively associated with increases in the harp seal population. Since 2000, it appears that ecological and hydrographical changes may have changed this relationship, and possibly led to decreases in the local abundance of harp seals in some areas. As a result, the positively correlated relationship between increases in the NWA harp seal population and the proportion of seals summering off Greenland no longer appear to exist. There are insufficient data available at this time to determine the reason for the change in the relationship.

At the request of the Marine Strategy Directive Framework Steering Group (MSFDSG) and the Strategic Initiative on Area Based Science and Management (SIASM), the WGHARP identified and described the work streams of relevance to the European Commissions eleven descriptors with particular emphasis on linkages that between living marine resources (rather than fish stocks alone) and ecosystem/environmental monitoring and assessments.

The WG noted that that many of the principles identified in the European Commission's request for advice on the Descriptors should be extended to all upper trophic level marine species, including harp and hooded seals. Other marine taxa including other marine mammals, marine birds and marine turtles should also be considered as part of this exercise. An almost singular advantage of harp and hooded seals is that their population abundance, catch history, distribution, condition (including life history parameters), and ecological relationships are better understood than most other North Atlantic Ocean upper trophic level taxa. Similar data are also available for a few other species (e.g., United Kingdom grey seals, Baltic Sea/North Sea harbour seals). As key components of their ecosystems, it is important to consider these species, particularly because they can provide excellent indicators of ecosystem status.

The SIASM report identifies a number of spatial planning and data needs that can be supported by data available on harp and hooded seals including abundance, changes in reproductive parameters, change in growth rates and condition, changes in distribution, and changes in diets. Data are also available on several of the other themes of information requested.

Finally, WGHARP members suggest that ICES and its WGs are structured to provide advice that is easily incorporated into the policy or planning advice, therefore the WG does not understand the intent of statements within the report suggesting the contrary. WGHARP also felt that it was not the role of scientists to advocate for particular outcomes. It is the role of managers and stakeholders to identify clear objectives and questions, and for scientists to provide an analysis of the likely outcomes. Managers and stakeholders will then be able to make decisions based on the best available analyses. It is also the role of scientists to identify the uncertainty, but managers must take into account this uncertainty and its implications when making decisions.

1 Opening of the meeting

The ICES/NAFO Working Group on Harp and Hooded Seals (WGHARP) met during 15-19 August 2011 at the British Sea Mammal Research Unit (SMRU) at the Scottish Oceanographic Institute, University of St. Andrews, Scotland. The WG received presentations related to 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 September 2010 request from Norway. The WG also responded to a request from NAFO to consider the impacts of the increasing northwest Atlantic harp seals on the number of seals near Greenland. The WG then acted on requests from the ICES Directorate and the EU to consider issues related to Ecosystem Based Management and Marine Spatial Planning. The WG concluded their meeting on 19 August. In attendance were scientists representing Canada (2), Greenland (1), Norway (3), Russia (2), and United States (1)(Annex 1), as well as the SMRU (3).

2 Adoption of the agenda

The agenda for the meeting, as shown in Annex 2, was adopted at the opening of the meeting on 15 August 2011.

3 Terms of reference

In September 2010 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:

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

1. *Current harvest levels,*
2. *Sustainable catches (defined as the fixed annual catches that stabilizes the future1+ population),*
3. *Catches that would reduce the population over a 10-year period in such a manner that it would remain above a level of 70% of current level with 80% probability*

An additional request was received from NAFO to evaluate how a projected increase in the total population of Northwest Atlantic harp seals might affect the proportion of animals summering in Greenland. Finally, the ICES Directorate also requested the WG to address issues with respect to Ecosystem Based Management and Marine Spatial Planning.

The purpose of the 2011meeting was to:

1. *Review results of 2010–2011 surveys*
2. *Provide quota advice to ICES/NAFO member states of their harvests of harp and hooded seals;*
3. *To evaluate how a projected increase in the total population of Northwest Atlantic harp seals might affect the proportion of animals summering in Greenland*

4. *Identify elements of the EGs work that may help determine status for the 11 Descriptors set out in the Commission*
5. *Provide views on what good environmental status (GES) might be for those descriptors, including methods that could be used to determine status.*
6. *Comment on the Report of the Workshop on the Science for area-based management: Coastal and Marine Spatial*
7. *Provide information that could be used in setting pressure indicators that would complement biodiversity indicators currently being developed by the Strategic Initiative on Biodiversity Advice and Science (SIBAS). Particular consideration should be given to assessing the impacts of very large renewable energy plans with a view to identifying/predicting potentially catastrophic outcomes.*
8. *Identify spatially resolved data, for e.g. spawning grounds, fishery activity, habitats, etc.*
9. *Provide advice on other issues as requested*

The WG convened at St. Andrews, Scotland in August 2011 to fulfil this purpose.

4 Harp seals (*Pagophilus groenlandicus*)

4.1 The White Sea and Barents Sea Stock

4.1.1 Information on recent catches and regulatory measures

A possible reduction in harp seal pup production in the White Sea may have occurred after 2003. Due to concern over this, ICES (2009) recommended that catch options should be based on the use of the Potential Biological Removal (PBR) approach, and annual removals were restricted to 30,062 animals in the White and Barents Sea in 2010 and 2011. This was under the assumption that the age structure of the removals was proportional to the age composition of the population (i.e. 14% pups). A catch consisting of a higher proportion of pups would be more conservative. The Joint Norwegian-Russian Fisheries Commission followed WGHARP's 2009 advice in setting the Total Allowable Catch (TAC = 30,062 animals) and allocated 7 000 seals of this TAC to Norway in both years. Russian sealing in both 2010 and 2011 was planned using the new boat-based approach introduced in the White Sea catch in 2008. This catch, using ice class vessels fitted with small catcher boats, would focus primarily on weaned pups. No white-coats would be taken. However, as was also the case in 2009, Russian authorities implemented a ban of all White Sea pup catches. Despite considerable effort from PINRO specialists to explain that a sustainable harvest from the population would be possible, the Russian authorities concluded that catches of animals less than one year old in the White Sea should be banned in 2010 and 2011. Consequently, there were no Russian harp seal catches in the White Sea in these two years, although a few animals were taken for scientific purposes in 2010. One Norwegian vessel had intended to conduct sealing operations in the southeastern Barents Sea in 2010. However, the operation lacked the necessary permissions from Russian authorities and had to be cancelled after only a few days of hunting – at this point the vessel had taken 105 1+ animals. The same vessel made a new attempt in the area in 2011. Due to a late start (departure from Tromsø on 20 April) there was very little ice left in the traditional hunting areas in the East Ice and only 200 1+ animals were taken. (Haug and Zabavnikov, SEA 195)

Biological material, to establish age distributions in catches as well as health, reproductive and nutritive status of the animals was collected by Norwegian and Russian personnel during the catch in 2011. The low number of animals taken resulted in few samples, and the WG recommends that effort is made to obtain material for scientific studies in future catches in the area.

4.1.2 Current research

In an attempt to assess possible reasons for the decline in the Barents Sea / White Sea harp seal population, Hammill & Stenson (SEA 208) modified the model currently used to assess the Northwest Atlantic harp seal population and fitted it to aerial survey estimates of harp seal pup production from the White Sea. This model requires annual reproductive data as an input, but unfortunately, these data are limited. The reproductive rates used in these simulations were based on age at maturity data from Frie *et al* 2003 and pregnancy rates of mature animals from ICES 2009. To obtain some temporal trend in reproductive rates, the age specific reproductive rates were changed in 3 blocks of time. It was also assumed that the fecundity rates had a coefficient of variation of 0.15.

An initial fit to the aerial survey data that incorporated reported harvests was unable to capture the marked decline observed in pup production between 2003 and 2005. It also suggested unrealistically high estimates of pup production and total population size with pup production in 1952 was estimated to be 5.35 million (SE=5.6 million) and the total population estimated to be 23.8 million (SE=24.3 million). The model estimated that 2010 pup production was 125,700 (SE=23,000) and a total population of 930,600 (SE=138,400). A scenario that assumed unreported removals of a large number of adults provided some improvement in fit to the pup production estimates. This scenario assumed a non-reported mortality of 100,000 animals aged 1+ occurring between 1999 and 2007. Under this scenario, no young of the year animals (YOY) were removed. This resulted in an estimated pup production of 487,200 (SE=212,000) and a total population of 2.17 million (SE=894,100) in 1952. Estimated pup production in 2010 was 130,500 (SE=23,400) animals and the total estimated population was 1.08 million (SE=166,100). A similar trajectory was obtained assuming adult removals of 50,000 between 1999 and 2007, and removals of 50,000 pups between 1991 and 2007.

Significant numbers of seals were caught in gillnet gear along the coast of Norway during 1986-1988 (Haug *et al*. 1991). Few animals who could have been born in these years were detected in later years, suggesting that mortality among these cohorts had been high (Kjellqwist *et al*. 1995). Thus could have either been because most of the young born in each of these years died, or mortality among newborns or intra-uterine mortality was high. IN either case it would appear that there had been a significant drop in pup production in those years. As a result, the population decline observed at the end of the 1990s would have been influenced to some extent by an absence of animals from the 1986-88 cohorts, which would have been 10-12 years old by 1998.

The best fit was obtained assuming that there was a marked reduction in the number of births between 2003 and 2005. This was obtained by assuming an increase in mortality (prior to the surveys) or reduction in the number of pups born of 50% during each year between 2004 and 2010. Estimated adult mortality was 0.07 (SE=0.01). This resulted in an estimated pup production of 409,300 (SE=222,000) and a total population of 1.84 million (SE=1.00 million) in 1952. Estimated pup production in 2010 was 136,400 (SE=24,300) animals and the total estimated population was 1.81 million (SE=280,500). Including a scenario that assumes high mortality of young from the 1986-1988 cohorts, as well as the high mortality between 2004-2010 results in an adult

M of 0.07 (SE=0.01), a 1952 pup production estimate of 397,200 (SE=215,300) and a total population estimate of 1.78 million (SE=927,300). In 2010, the estimated pup production was 137000 (SE=24,000) and the total population size was estimated to be 1.85 million (SE=242,100).

In summary, the changes in the population caused by the removal of adult seals produced a decline in the population that improved the fit to the pup production survey estimates slightly, but the decline was gradual, whereas the sudden drop in pup production, caused from applying the mortality factor of 50% to the birth term in the model beginning in 2004, allowed the model to fit the survey data quite well. This change could be accounted for by a marked decrease in late-term pregnancy rates due to intra-uterine mortality, unusually low pregnancy rates in the selected years, or an extremely high mortality at birth, where animals disappeared prior to being counted.

Korzhev (SEA 210) presented results from mathematical modelling designed to estimate total population abundance and to develop recommendations concerning harvesting strategy. Three models were presented: the traditional NE model; a modified cohort model with rates of natural mortality and maturation which are dependent on density; and a production model based on Schaefer's equation of logistic production growth using Potential Biological Removal (PBR) to estimate catch removals. The analyses showed that none of these models could adequately describe the drastic variations in pup abundance observed during the most recent 10-year period. Therefore they cannot provide precise estimation for the population abundance. Nevertheless, taking into account the prevailing low recruitment to the population, and the low harvesting activities in the most recent 5 years, the modelling efforts seems to suggest that the population abundance for 2011 could be estimated at 1.1-1.2 million animals. Despite the data-richness of the population, Korzhev (SEA 210) recommended to use the PBR approach which would result in feasible catches of 31-32,000 animals for the period 2012-2013.

The WG agreed with the conclusion that none of the applied models provided a good fit to the variability in pup production over the period 1998-2010. Among the different versions of the traditional cohort model, only a model assuming an initial population size of nearly 10 million seals in 1946 showed a clear decline in pup production from 1998 to present, although the modeled decline did not fit the observed pup production. Regardless of choice of initial abundance, the traditional NE model estimated total abundance for 2010 at 1.1-1.2 million. This estimate compares relatively well with the Norwegian estimates for 2011 that ranged from 1.4 to 1.6 million seals (Øigård *et al.*, SEA 197), but would result in more conservative catch options.

Based on the significant and prolonged initial decline in abundance modeled by the production model for a PBR based harvesting regime, the WG had serious concerns regarding the appropriateness of this approach for evaluation of the potential effect of catches based upon PBR. Although the model suggested that there would have been a significant positive trend in abundance after the 1970s resulting in a total population size of about 3 million seals in 2010, the WG found that the uncertainties about the general model performance were too great to provide convincing support to a PBR based harvesting regime.

Using Russian “Pulsar” satellite telemetry sensors, linked to the Argos system, Svetochev (SEA 200) caught and tagged 4 weaned harp seal pups (“beaters”) in the White Sea in March-April 2010. During April the tagged beaters remained on the ice, and their moves were entirely determined by ice drift driven by wind and currents. Once they were out of the White Sea, the beaters began active swimming in Barents Sea waters. Three of the seals reached the edge of the drifting ice in the north during the period August - October, whereas one seal remained in open waters further to the south. The transmitters lasted from 159 to 394 days, and during the entire study period 3 of the seals remained in the Barents Sea, whereas one made a westward migration into the Norwegian Sea (west of Spitsbergen). Two of the seals returned during winter along the edge of the annual ices west of Novaya Zemlya to the southeastern part of the Barents Sea.

The WG noted that the migratory patterns of the 4 beaters were similar to migration patterns observed in a more comprehensive experiment that also included adult seals that was carried out in this area during the mid 1990s (Nordøy *et al*. 2008). The group commended the work by Svetochev (SEA 200) and recommended that similar work be continued in the future, either with the simple transmitter type used in this experiment or with more sophisticated transmitters. Haug and Zabavnikov informed the group that such experiments had been planned by Norway and Russia for several years, but the project ran into permitting problems because the Federal Technical Committee in Russia has forbidden all satellite tagging with foreign tags in Russian waters. Tagging seals in the White Sea is still a high priority task for Norway and Russia, and the plan is to for a new tagging effort in 2012. PINRO, Russia, will apply for permission to tag seals and will be responsible for organizing the logistics required for a vessel-based live catch of seals in May 2012, while IMR, Norway, is responsible for the satellite tags, including providing all necessary technical details, as well as for providing experienced personnel and equipment for anaesthetizing seals and tag deployment. The WG strongly recommends that this experiment be carried out.

4.1.3 Biological parameters

In previous studies of Barents Sea harp seals, observations have indicated that poor condition of juvenile and adult seals could be linked to reduced recruitment to the stock. In a Norwegian sampling program conducted during April/May in 1992-2011 onboard Norwegian sealers operating in the southeastern Barents Sea (the East Ice), body condition data were collected from a large number of juvenile and adult harp seals. The data were analyzed to determine if there are some year-to-year variations, in particular if there are some changes after 2003 when the decline in recruitment occurred (Øigård *et al.*, SEA 196).

The resource situation of the Barents Sea ecosystem has varied much over the past 40 years; high abundance of capelin has been replaced by high abundance of herring and krill and vice versa. Also, the stocks of polar cod and cod have fluctuated greatly. There is good evidence to suggest that Barents Sea harp seals respond to changes in ecosystem properties, however, we do not understand the functional predator-prey relationships. Recent Russian aerial surveys, to assess the pup production of this stock in the White Sea in 2004, 2009 and 2010, indicate a decline in pup production. This decline could be caused by a food shortage leading to poor body condition, which in turn reduced pregnancy rates and resulted in lower pup production. The main objective of this study was to analyze the functional relationship between harp seals body condition and the biomass of major harp seal prey (krill, capelin, herring, polar cod and cod) using general additive models (GAM). The harp seal body condition data were sampled in the southeastern Barents Sea (the East Ice) during moult (April/May) in 1992-2011. Resource data were taken from published literature or stock assessment reports.

Results from the GAM analysis suggests that the body condition of juvenile and adult harp seals varied significantly between years, increasing from 1992 until 2001 and then leading to low body condition in 2011. A significant year effect on pup's body condition was found. There was no difference in body condition between genders. Using available abundance estimates (biomasses) of capelin, polar cod and krill (the previous year) as predictors suggests significant predator-prey relationships. Choosing an optimal model, in terms of combination of available abundance of prey species, for the condition of the harp seals is difficult due to strong correlations between the predictors. However, it is clear that the amount of prey available certainly affects the condition of the seals. Nevertheless, the body condition of juvenile harp seals was significantly correlated with by the available biomasses of polar cod, cod and krill. Cod had a linear negative relationship to body condition (i.e., the body condition declined linearly with increasing biomass of cod.) The relationship between polar cod biomass and seal condition was positive, until the biomass of polar cod reached a certain level after which the effect was negative. The relationship between krill biomass and seal condition was also positive until the biomass of krill reached a certain level, and then the relationship appeared to level off. The predator-prey relationship for adult seals differed slightly from that of the juveniles; increasing biomass of capelin, polar cod, and cod had a significant negative impact on the body condition of adult seals, whereas krill had a positive impact on the body condition. The condition declined and increased linearly with increasing biomass of polar cod and krill, respectively, whereas for cod and capelin the decline flattened out beyond a certain biomass threshold. The functional relationship between the body condition of adult females and pups was also analyzed and the results indicate a positive relationship (i.e., poor body condition of pregnant females resulted in poor body condition of pups.)

The WG noted that the study was very interesting and encouraged that more work be done on this approach where biological data on seals are linked to other components of the ecosystem. It would be of particular interest to assess whether observed variations in condition affected the reproductive rates of the population. Time series on condition data and prey data should be continued, and also information on another key prey group (amphipods of the genus *Themisto*) should be obtained. Further collaboration with Russian and Canadian scientists, preferably also scientists from institutions such as SMRU, on this research should be established.

4.1.4 Population assessment

Pup production

Pup production estimates for 2010 were based on multispectral survey data (infrared [IR] and digital RGB imagery) obtained from aerial surveys flown during 20-23 March 2010 (Zabavnikov & Shafikov SEA 206). The total pup production estimate was 163 032 (SE=32 342). This value is slightly higher than the result obtained in 2009, higher than in 2005 and 2008, but still less than observed in 2004 and in 2000-2003.

Before, during and short time after the survey, traditional ice condition monitoring was carried out using all available internet sources including ENVISAT radar data, information of North Hydro Meteorological Centre from Archangelsk (NHMC) and Company ScanEX from Moscow. Under current observed and forecasted ice conditions, the pupping period was assumed to begin and finish later than in 2009 (Vladislav Svetochev, MMBI, Russia, pers. comm.).

Prior to the multispectral survey, reconnaissance flights were conducted in the entire White Sea area on 8, 15, and 19 March. During these flights, observations were made of ice condition, localization of main breeding patches, and the progress in breeding activity. Little active whelping (determined by the presence of blood on the floes) was observed on 8 March. Increasing numbers and area of blood spotted floes was observed by 15 March. Thus, it was assumed (based on analyzes of current observed and forecasted ice conditions, taking into account also information on ice drift (from NHMC) and above mentioned reconnaissance flights) that the starting date of the multispectral aerial survey (20 March) was convenient to get pup production numbers data near the peak of pupping.

The ice conditions in 2010 were considerably better for harp seal whelping than in 2008 and 2009, and closer to the situation observed in 2002-2003 when the highest estimates of total pup production were recorded. The entire survey period was characterized with calm, stable winter weather.

As in previous multispectral aerial surveys all track lines were flown along longitudes with a transect spacing of 7.5 km. It was started from the border between ice and open water (no ice) or coastal line and finished in border between ice and open water or in coastal line. The most considerable whelping patches were observed in areas where ice concentrations were between 70-90%. According to information from the NHMC, the ice drift was very slow and passive inside the White Sea. Satellite monitoring of ice drift was not conducted.

The highest pup production density was recorded in the southeastern part of the "Basin" in the White Sea, close to the border with the Dvinsky Gulf. In other areas of the White Sea densities were similar or much lower, and in adjacent southeastern areas of the Barents Sea (Cheshskaya Bay and outside it) only very scattered adults with pups were observed.

As in 2008-2009, walruses were observed in the harp seal whelping patches in 2010, presumably feeding on pups. The icebreaker and vessels activity observed in the area in previous years, which was considered to a potentially important source of mortality, did not occur in 2010. PINRO, NHMC and the World Wildlife Fund changed the shipping route, as a result of efforts so that ships passed to the south and around the harp seal whelping patches.

The WG agreed that the 2010 survey appeared to have been conducted appropriately. Reconnaissance and monitoring of ice conditions were thorough, and a complete area was surveyed rather quickly, which minimized the potential for drift (double counting) or loss of significant numbers of animals from the area. Also, potential new areas in the southeastern parts of the Barents Sea were surveyed as previously requested by the WG.

The WG noted that although whelping activity appeared to be later in 2010 than in 2009, this was based on qualitative information only (observations of fresh blood spots on the floes). The proportion of pups in different developmental stages is a much better cue to monitor whelping, and should preferably be obtained from on-ice surveys carried out throughout the survey period. There were some concerns in the group over the late timing (20-23 March) of the 2010 survey which may have negatively biased the estimate.

The ice conditions in the White Sea in 2010 were more favourable for survival of pups than in previous years. Zabavnikov & Shafikov (SEA 206) also reported the ice conditions in the White Sea in March 2011; this was also a year with good ice conditions for harp seal whelping.

As a result of both the 2009 and 2010 surveys, the WG felt that the reduced pup production observed since 2004 does not appear to be a result of poor survey timing, poor counting of imagery or the disappearance of pups from the survey areas prior to the survey. The remaining possibilities to account for the reduced pup production since 2004 include reduced adult recruitment due to past juvenile mortality, unobserved mortality of adults in recent years, reduced female fertility, or a shift in contemporary pupping to areas outside of the traditional areas. During the late 1980s or early 1990s, some reports of harp seal pups being observed in Svalbard were received. Therefore, the WG felt that it was important that areas in the northern Barents Sea and Kara Sea be searched during future surveys.

Population models

In the previous meeting, the WG concluded that the traditional NE Atlantic population model was unable to capture the sudden drop in pup production in the White Sea observed after 2003 (ICES 2009). The fit to the observed survey data was extremely poor and the predicted estimate of 2009 pup production was unrealistic in comparison to the observed pup production. The model uses a constant maturity ogive over the entire time period. Considering the changes observed in reproductive rates in this population, the WG recommended that the existing model be modified to allow for non-constant reproductive rates. It also suggested that mortality associated with the poor condition and seal 'invasions' of the mid 1980s and 1995 be incorporated into the model to determine if changes in the age structure associated with these poor cohorts may have an impact on the current population.

Øigård *et al*. (SEA 197) presented an analysis exploring three different model scenarios. The basic population model was the age-structured, fixed reproductive parameter NE model. A second model, as requested at the 2009 WGHARP meeting, used the NE model but with time-varying reproductive data. The model uses historical catch data and estimates of pup production in order to estimate the current total population. A similar model is used to assess the abundance of the NW Atlantic harp seal population (ICES, 2005) and for assessing the historical population of the Barents Sea harp seals (Skaug *et al*., 2007). The following parameters are used in the model.

- $N_{0,t} \sim$ number of pups born in year t.
- $N_{i,t} \sim$ number of individuals of age i in year t.
- $N_{t_0} \sim$ population size in year t_0 = 1945.
- $\boldsymbol{M_0} \sim$ mortality rate for pups.
- $\boldsymbol{M_{1+}} \sim$ mortality rate for 1+ age group.
- $\boldsymbol{p_{i,t}} \sim$ proportion of mature females at age i in year t.
- $\boldsymbol{F_t} \sim$proportion of females giving birth in year t.

The "1+" denotes all ages older than or equal to 1 year.

The mortality rates M_0 and M_{1+} determine the survival probabilities $s_0 = \exp(-M_0)$ and $s_{1+}=\exp(-M_{1+})$, which are the quantities that appear in the population dynamics equations that follows. As in past models, this model uses a constant mortality rate for animals 1+ old because available data do not allow age specific Ms to be estimated.

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

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

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

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

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

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

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

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

where $N_{1+,t} = \sum_{i=1}^{A} N_{i,t}$. The model has the following set of recursion equations:

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

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*.

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

$$D_{1+} = \frac{N_{1+,2021}}{N_{1+,2011}}. \tag{6}$$

The estimated parameters are the initial population, N_{t_0} along with the biological parameters M_0 and M_{1+}. These are found by minimizing an objective function consisting of the sum of squares of the differences between the model value and the survey estimates of pup production. To minimize the total objective function the statistical software AD Model Builder (ADMB Project 2009) is used. AD Model Builder calculates standard deviations for the model parameter, as well as the derived parameters such as present population size and D_{1+}. AD Model Builder uses a quasi-Newton optimization algorithm with bounds on the parameters, and calculates estimates of standard deviations of model parameter using the "delta-method" (Skaug *et al*., 2007). The catch data enter the model through Eq. (4), but do not otherwise contribute to the objective function. As the model involves prior distributions on some parameters, the analysis has a Bayesian flavour.

Reproductive rates

Øigård *et al*. (SEA 197) ran the population model under three scenarios of reproduction data.

One scenario was the previously used model presented in ICES (2009) run with constant maturity curve, p_i, and constant pregnancy rate F estimated from the most recent reproductive sample from 2006 (see Table 1 and Table 2). This data set was presented in detail at the last WGHARP meeting (ICES 2009).

The second scenario is the new adjusted model with time varying maturity curve, $p_{i,t}$, and time varying pregnancy rate F_t (see Table 1).The values used for the maturity curve are historical estimates based on Frie *et al.* (2003) and the latest estimate from 2006 (ICES, 2009). Only four maturity curves are available. In periods with missing estimates we used linear interpolation to estimate the maturity curve. Note that this assumes a smooth (linear) transition of the birth ogive curve in the years that maturity data are not available. This is illustrated in Figure 1. Recent and historical data of the pregnancy rate F_t is found in Table 2. Historical data on pregnancy rates for the period 1990-1993 are taken from Kjellqwist *et al* (1995). A linear transition was assumed for periods with missing pregnancy rates (i.e., a linear transition from 0.84 in 1990 to 0.68 in 2006). In the periods before 1990 the pregnancy rate was assumed constant at 0.84. In the periods after 2006 the pregnancy rate was constant at 0.68.

Table 1. 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 Frie *et al*. (2003) and ICES (2009).

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 2. Estimates of proportion of females giving birth. Data from Kjellqwist *et al* (1995) and ICES (2009).

Year	Estimated F
1990-93	0.84
2006	0.68

A third and more preliminary scenario was presented to initiate a discussion in order to stake out possible future research. The maturity curve was the same as used in the modified model with historical reproductive rates. A strong correlation between the condition of harp seals in the Barents Sea / White Sea and the survey pup production estimates has been observed. Thus, a correlation between the condition of seals and the pregnancy rate was assumed. In studying the condition of Barents Sea / White Sea harp seals, using available data from the period of 1992 – 2011, a smoothed estimate using an additive model was obtained and used as a shape for the pregnancy rate. To form a time varying pregnancy rate, this smoothed estimate was scaled within the range of the lowest pregnancy rate observed and the highest pregnancy rate observed.

Survey pup production estimates and catch history

Pup production estimates are available from surveys conducted in 1998 – 2010. These are found in Table 3. Catch data span the period 1946-2011.

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 (2009) and from Zabavnikov & Shafikov (SEA 206.).

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	322,474a 339,710b	0.098 0.105
2002	20 March	330,000	0.103
2003	18 & 21 March	328,000c	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	163,032	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.

Population estimates

The estimated population sizes, along with the parameters for the normal priors used, applying the three model scenarios, are presented in Table 4. The mean of the prior for M_0 was taken to be three times that of the mean of M_{1+}. The model estimates seem to be stable for various choices of precision of the prior of M_{1+}. Also changes in the mean of the prior of M_{1+} did not affect the model estimates.

Neither the original model nor the modified model using historical data were able to capture the observed survey pup production estimates properly, while thee fit of the model using a condition modulated pregnancy rate was able to capture the observed survey data well (Fig 1). All models show similar trend of the 1+ abundance from 1946 to early 1960. Scenario 1 and 2 show an increase in the 1+ population from early 1960 to today, and future model predictions, assuming no hunt, indicate a future increase of the population from 13% – 36% in the next 10 years. Model scenario 3 shows an increase in the population from early 1960 to around 2005, and then the population drops rapidly. Model predictions indicate a reduction in population size (assuming no hunt) of 14%.

Selecting the model which provides the best model fit, i.e. the model with condition modulated pregnancy rate, a 2011 abundance of 1,485,000 1+ animals and 142,700 pups is obtained. A 95% confidence interval for the 1+ population is (1,293,460 – 1,676,540). The total 2011 population of harp seals in the East Ice therefore counts 1 627,700 (1,435,426 – 1,820,074) seals of all ages. Under this scenario the model indicates a 14% reduction of the abundance of 1+ animals in the next 10 years assuming that the pregnancy rate remains low and there is no hunt.

The model scenario using historical reproductive data provides a 2011 abundance of 1,172,000 (1,039,240 – 1,304,760) 1+ animals and 192,700 pups. Total estimate is 1,364,700 (1,230,384 – 1,498,916). Although this scenario provides a poor fit to the observed survey pup production data, but the WG felt that this option provided a more reasonable future prediction than the third model scenario, which assumed a future prediction using very low pregnancy rates.

Table 4: Barents Sea / White Sea harp seals: 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	Traditional NE model		Time varying NE model		NE model with historical values of $p_{i,t}$ and condition modelled F_t	
	Mean	SD	Mean	SD	Mean	SD
N_{t_0}	1 639 253 (1 000 000)	128 090 (200 000)	1 372 033	122 590	1 181 366	105 220
M_0	0.33 (0.30)	0.05 (0.05)	0.35	0.05	0.30	0.05
M_{1+}	0.10 (0.09)	0.03 (0.008)	0.11	0.01	0.09	0.01
$N_{0,2011}$	205 000	10 785	192 700	10 216	142 700	8 879
$N_{1+,2011}$	1 212 000	70 029	1 172 000	67 737	1 485 000	97 722
$N_{Total,2011}$	1 417 000	70 855	1 364 700	68 503	1 627 700	98 125
D_{1+}	1.36	0.06	1.13	0.06	0.86	0.05

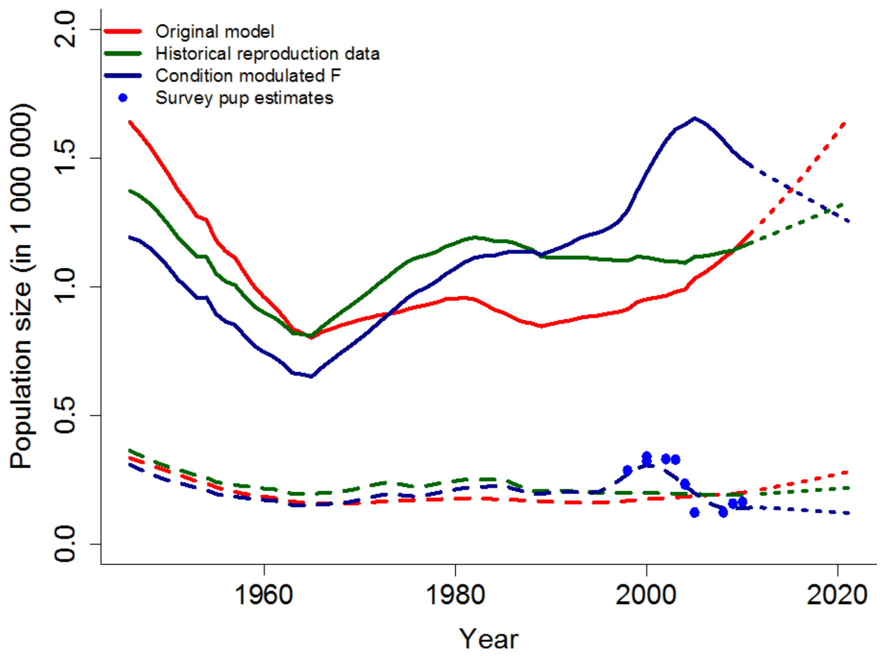

Figure 1. Modelling the Barents Sea / White Sea harp seal population: Population trajectories for pups (dashed lines) and the 1+ population (full lines) for all three scenarios. The dotted lines show model predictions, blue dots are survey pup production estimates.

At its previous meeting, the WG had concluded that the rapid decline in pup production observed after 2003 was not a consequence of the survey methods used. Øigård *et al* (SEA 197), Hammill and Stenson (SEA 208) and Korzhev (SEA 210) explored various scenarios but were unable to duplicate the decline using the available reproductive or mortality data. The WG identified three possible explanations for the rapid, and continued, reduction in pup production:

1. There was a large mortality of young prior to the surveys, possibly due to poor ice conditions. The fact that the estimates remain low even though ice conditions have varied and in fact were quite good in 2010, suggests that this hypothesis is unlikely.
2. A large mortality of adults beginning in 2004 improved the fit of the model to the decline but did not capture the changes well. Also, there has been no evidence of a large mortality (>100,000) that would be required to effect the change in pup production observed. Dead seals were observed during the mid 1980s when such mortality occurred, but have not been seen since. If a large mortality occurred, pup production will remain low for 8-10 years, but then increase as new cohorts become sexually mature.
3. The most likely explanation for the change in pup production is a decline in the reproductive state of female harp seals. Reducing fecundity in the models (Øigård *et al*., SEA 197; Hammill and Stenson, SEA 208) does produce estimates that mimic the changes observed. Moreover, changes in condition of adult seals (Øigård *et al*., SEA 196) were observed during this time period which likely impacted pregnancy rates.

Although the hypothesis that changes in the pregnancy rates occurred in the mid 2000s appears to be the most plausible, the WG felt additional research is required before this model can be used to provide advice. The impact of range of possible fecundities chosen should be explored and methods of extrapolating to future populations must be developed. The WG recommended that this modelling approach be continued in order to develop a useable model for providing advice.

In their last meeting, the WG concluded that the model that used constant parameters for the maturity ogive and fecundity was not appropriate and requested that the model be modified to include changes in reproductive parameters derived from the data. This model uses all of the available data and provides a reasonable fit to the 2010 pup production estimate. It also provides the most conservative estimate of the current population. Therefore, the WG felt that this model could be used to provide advice at this time. However, these model projects future populations assuming a fecundity rate of 64% although the pup production data suggests that fecundity may be lower. If so, the model may be over estimating future fecundity and underestimating the impact of catches.

To further develop the model that incorporates annual changes in fecundity, the WG recommends that condition and reproductive data be collected concurrently, particularly in years when surveys are being carried out.

4.1.5 Catch options

Based on current data availability and the criteria agreed to previously (3 surveys within the past 15 years, one survey within the past 5 years, recent data on reproductive rates), the WG considered the Barents Sea / White Sea harp seal population to still be data rich, and above the N_{70} level (i.e., more than 70% of known maximum abundance measured) defined by ICES (2008). Thus, it is appropriate to provide catch advice using the assessment model.

Due to the preliminary state of the model with a pregnancy rate modulated fit condition data, the WG agreed to use the model scenario using time-varying historical reproductive rates in defining catch options. The WG had been requested to give options for various catch scenarios:

1. Current catch level (average of the catches in the period 2007 – 2011).
2. Sustainable catches (defined as the fixed annual catches that stabilizes the future 1+ population)
3. Catches that would reduce the population to 70% of current level with 80% probability over a 10-years.

The estimates for the various catch options are given in Table 5. By incorporating the full range of reproductive data available, the model provides a new (and lower) estimate of the total population. The catch options provided are, therefore, also lower than the catch options provided at the WGHARP meeting in 2009. This is a result of the new estimate of the total population. A population increase of about 11% is predicted over the next 10 years with current catch levels. Sustainable catches are 26,535 (whereof 74.6% should be pups) or 15 827 (100% 1+ animals). Catches that would reduce the population to 70% of current level with 80% probability over a 10-years are 37,800 (whereof 74.6% should be pups) or 25,000 (100% 1+ animals).

Table 5. Catch options with relative population size (D1+) in 10-years (2021) for harp seals in the Barents Sea / White Sea.

Option #	Catch level	Proportion of pups in catches	Pup catch	1+ catch	Total catch	D_{1+}		
						Lower CI	Point	Upper CI
1	Current	74.6%	3 771	1 285	5 056	1.00	1.11	1.23
2	Sustainable	74.6%	19 795	6 740	26 535	0.89	1.00	1.12
3	Sustainable	0%	0	15 827	15 827	0.90	1.01	1.13
5	Reduce to N_{70}[a]	74.6%	28 199	9 601	37 800	0.83	0.95	1.06
6	Reduce to N_{70}[a]	0%	0	25 000	25 000	0.84	0.95	1.06

[a)] Catches that would reduce the population to 70% of current level with 80% probability over a 10-years.

4.2 The Greenland Sea Stock

4.2.1 Information on recent catches and regulatory measures

The 2010 and 2011 TAC set for harp seals in the Greenland Sea was set at 42,400 1+ animals (where two pups balance one 1+ animal), i.e., the removal level that would reduce the population while still maintaining it above the N_{70} level with 80% probability over the next 10 year period. The background for this was the seal management plan developed and approved by ICES (ICES 2008). Using this approach, the TAC was set by Norway based upon their calculations. For economical reasons, Russia has not participated in this area since 1994. Total catches in 2010 (performed by one single vessel) were 4,678 (including 2,823 pups) harp seals, whereas 4 vessels took 10,134 (including 5,361 pups) harp seals in the area in 2011. The removals represented 11% and 24% of the identified sustainable levels in 2010 and 2011, respectively (Haug and Zabavnikov, SEA 195).

4.2.2 Current research

No new information.

4.2.3 Biological parameters

No new information.

4.2.4 Population assessment

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) defined by ICES (2008).

The Population model

The population model used to assess the abundance for the Greenland Sea harp seal population by Øigård *et al*. (SEA 198) is an age-structured population dynamics model. It uses historical catch data and estimates of pup production in order to estimate the current total population. The model is similar to the model assessing the abundance of the Barents Sea / White Sea harp seal population and has been modified to incorporate historical reproductive rates.

Reproductive rates

In response to requests by the WG (ICES 2009) the model has been changed to incorporate historical values of F (Table 6) available from a Russian long-term data set and a new Norwegian data from 2009 (Frie SEA 185). 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 (Frie SEA 185). Hence, the pregnancy rate is no longer estimated, but considered a known quantity. In periods where data are missing, a linear transition between estimates is assumed. Figure 2 shows the available historical pregnancy rates and the linear transition in periods with missing data.

The WG encourages research on the relationship between the condition of seals and pregnancy rates for harp seals in the West Ice.

Table 6. Reproduction rates, F_t, for harp seals in the Greenland Sea. From (Frie SEA 185).

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

The proportion of mature females at age *i*, p_i, is no longer assumed to be constant for all years. The NE model utilize historical data of the maturity curve $p_{i,t}$ (Table 7). The historical data of the maturity curve is sparse, consisting of only two curves. One curve is from the period 1959 – 1990 and the other is from 2009. In the period 1990 – 2009, where data are missing, a linear transition between the two curves was assumed.

Table 7. Greenland Sea harp seals: Estimates of proportions of mature females (pi,t). The P1 estimates are from the period 1959 - 1990 Frie (SEA 185) and the P2 estimates are from 2009.

Age	1	2	3	4	5	6	7	8	9	10	11	12	13
P_1	0	0	0.06	0.29	0.55	0.74	0.86	0.93	0.96	0.98	0.99	1.00	1.00
P_2	0	0	0	0	0.06	0.28	0.55	0.76	0.88	0.95	0.98	0.99	1.00

The model was run for two scenarios. One was the traditional NE model with constant reproduction rate and constant maturity curve for all years. The other was the time variant NE model utilizing historical data for the maturity curve and reproduction rates. The model estimates the abundance of seals from 1946, and because no historical data between 1946 and 1959 are available, the maturity curve was held constant from 1946 – 1990.

Survey pup production estimates and catch history

Pup production estimates are available from mark-recapture estimates (1983-1991) and aerial surveys conducted in 2002 and 2007. These are found in Table 8. Catch data are from the period 1946 – 2011.

Table 8. Estimates of Greenland Sea harp seal pup production. Based on data from Salberg et al (2008) and Øigård et al. (2010), and original working papers presented to WGHARP. The data from 1983-1991 are mark-recapture estimates; those from 2002 and 2007 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

Population estimates

The estimated population sizes, along with the parameters for the normal priors used, applying the two model scenarios, are presented in Table 9. The mean of the prior for M_0 was taken to be three times that of the mean of M_{1+}. The model estimates seem to be stable for various choices of precision of the prior of M_0 and M_{1+}. Also changes in the mean of the prior of M_0 and M_{1+} did not affect the model estimates much.

All model runs seem to indicate a substantial increase in the population abundance from the 1970s and up to now (Fig. 2). The time variant NE model provides a 25% lower population estimate than the original NE model. All model predictions indicate an increase in the abundance of 1+ animals on a 10 year scale, ranging from an increase of 31% - 49%, assuming no hunt.

Using the time varying NE model, a 2011 abundance of 553,100 1+ animals and 96,470 pups are obtained. A 95% confidence interval for the 1+ population is (286,480 – 819,720). Total 2011 abundance of harp seals in the Greenland Sea is 649,566 (379,031 – 920,101). By incorporating the full range of reproductive data available, the estimate provided by the model is lower than estimates provided by the original model.

Table 9: Greenland Sea harp seals: 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	Traditional NE model		Time varying NE model	
	Mean	SD	Mean	SD
N_{t_0}	344 670 (900000)	63 755 (900000)	249 777	37 992
M_0	0.22 (0.24)	0.2 (0.2)	0.28	0.2
M_{1+}	0.10 (0.08)	0.02 (0.1)	0.11	0.02
F	0.79 (0.81)	0.02 (0.2)	NA	NA
$N_{0,2011}$	124 800	24 922	96 470	23 401
$N_{1+,2011}$	744 700	185 400	553 100	136 030
$N_{Total,2011}$	869 500	187 068	649 570	138 028
D_{1+}	1.49	0.13	1.31	0.15

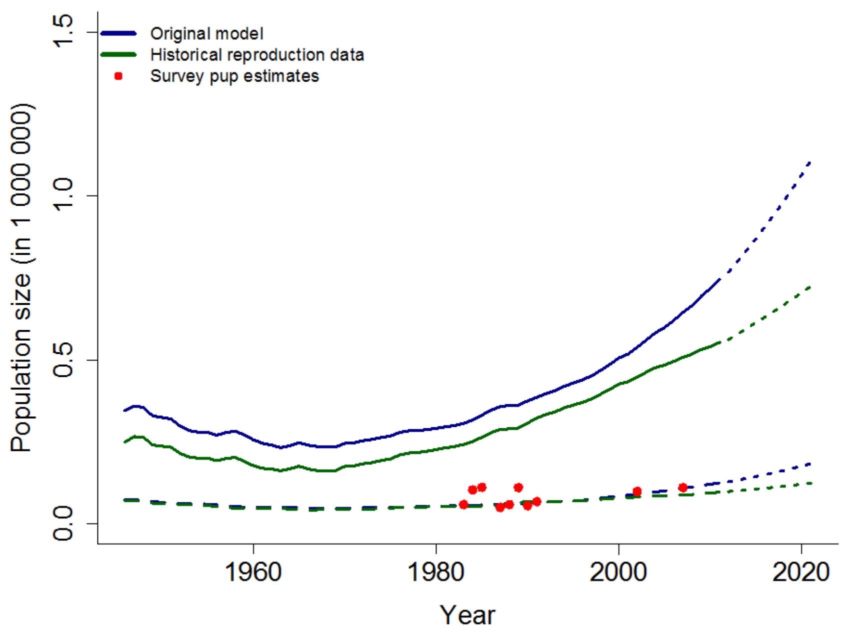

Figure 2. Greenland Sea harp seals: Estimated model trajectories for various reproduction rates. Full lines show 1+ abundance, dashed-dotted lines show pup abundances, and dashed lines show predictions from the original and time varying models. Red dots are estimated pup production.

4.2.5 Catch Options

The WG was requested to give options for various catch scenarios of harp seals in the Greenland Sea:

1. Current harvest level (average of the catches in the period 2007 – 2011).
2. Sustainable catches (defined as the fixed annual catches that stabilizes the future 1+ population)
3. Catches that would reduce the population to 70% of current level with 80% probability over a 10-years.

The estimates for the various catch options, using the new and modified population model, are given in Table 10. Current catch level indicates a 23% increase of the population size. Sustainable catches are 25,410 (63.4% pups) or 16,737 (100% 1+ animals). An annual catch level of 35,000 (assuming 63.4% pups) or 25,000 (assuming 100% 1+ animals) would reduce the population to 70% of current level with 80% probability over a 10-years period.

Table 10. Catch options with relative population size (D1+) and 95% confidence intervals in 10-years for harp seals in the Greenland Sea. The model with historical reproduction parameters is used when evaluating these catch options.

Option #	Catch level	Proportion of pups in catches	Pup catch	1+ catch	Total catch	D_{1+}		
						Lower CI	Point	Upper CI
1	Current harvest	63.4%	4 046	2 341	6 387	0.92	1.23	1.54
2	Sustainable harvest	63.4%	16 110	9 300	25 410	0.61	1.00	1.40
3	Sustainable harvest	0%	0	16 737	16 737	0.65	1.02	1.40
5	Reduce to N_{70}[a]	63.4%	22 190	12 810	35 000	0.45	0.89	1.32
6	Reduce to N_{70}[a]	0%	0	25 000	25 000	0.46	0.88	1.31

[a)] Catches that would reduce the population to 70% of current level with 80% probability over a 10-years.

4.3 The Northwest Atlantic Stock

4.3.1 Information on recent catches and regulatory measures

The Canadian 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. Following a new assessment (Hammill and Stenson 2009a), the TAC was increased to 330,000 in 2010 and 400,000 in 2011. There is no specific allocation or quotas for catches in Arctic Canada.

Canadian catches have steadily declined since 2006 when 354,867 harp seals were reported (1.06% of the TAC; Annex 7 Table 3). However, the statistics for this year assumed that 2,000 seals were taken in the Canadian Arctic which is double the harvest level assumed by Stenson (2009). In subsequent years, Arctic catches were not included in the estimates but are thought to be less than 1,000 animals. Canadian commercial 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. Although quotas have been increased since then, catches have been extremely low, falling to 27% and 21% of the quotas in 2009 and 2010, respectively. A combination of low prices, poor ice conditions, reduced effort and alternate fisheries resulted in a catch of only 38,018 in 2011 which is less than 10% of the TAC.

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 data on Greenland catches show a decline from 93,318 to 71,716 during the last 4 years for which data are available (2006-2009, Annex 7 Table 5). The trend in catches has been the opposite in north- and southwest Greenland, with more seals caught in north, but significantly fewer in south. The decline in catches in south may partially reflect reduced hunting effort. However, the number of seals in the area appears to be greatly reduced in recent years although there are no quantitative data to confirm this.

4.3.2 Current research

Research on diet, reproductive rates, growth, condition and habitat use are continuing. The primary focus of this research is to investigate the role of harp seals in the northwest Atlantic ecosystem, The impact of climate change on harp seals in the northwest Atlantic are being investigated, particularly with respect to how they cope with poor ice conditions. Changes in biological parameters are being monitored to determine how they may respond to density dependent factors or changes in prey availability.

The total extent of ice suitable for whelping harp seals in the Gulf of St. Lawrence and of the coast of southern Newfoundland conditions during 2010 and 2011 were at, or near, the lowest since 1969. Stenson and Hammill (SEA 209) examined how harp seals responded to these poor ice conditions. They observed that seals used unsuitable ice, moved to other areas, extending the whelping period and pupping outside of historical areas. There was no evidence to indicate that harp seals whelped on land even in areas where ice was absent. Young seals that did drift to shore had high levels of abandonment and mortality. The specific responses of whelping seals to poor ice conditions were influenced by the amount and timing of ice development in the different whelping areas. It is likely that mortality of young was high in both years, but likely greater in 2010 and 2011.

4.3.3 Biological parameters

Obtaining accurate estimates of fecundity are critical for estimating the population dynamics of a species. Annual estimates of late term pregnancy rates, fecundity and mean age of sexual maturity of Northwest Atlantic harp seals were obtained from samples collected off the coast of Newfoundland and Labrador between 1954 and 2008 (Stenson and Wells SEA 203). Pregnancy rates among 3 year olds remained low (<10 %) throughout the time period while those of 4 and 5 year olds initially increased during the 1970s, but declined by the mid 1980s to levels similar to, or lower than, those seen in the 1960s. Pregnancy rates of older seals remained high until the mid 1980s, but then declined to their current low levels. Annual fecundity rates are highly variable. Although they remained high (>85%) until the late 1970s, they subsequently declined and remain low. The proportion of mature females that were pregnant was particularly low (<40%) in 2004, which was a survey year. Reproductive rates increased to approximately 70% in 2008, another survey year, which may account for the rapid increase in pup production observed between these two surveys. Preliminary data from 2009 through 2011 indicate that fecundity rates have declined and may be in the order of 30% during the last two years. Late term abortions have been observed among late term reproductive samples. The proportion of females that have aborted has varied greatly but appears to be inversely correlated with the fecundity rates. However, these abortions cannot account for all of the variation observed in the annual pregnancy rates.

Estimates of the mean age of sexual maturity (MAM, Stenson and Wells SEA 203) were variable prior to the late 1970s but were generally above 5 years of age. From 1980 through 1987, however, the MAM drop to 4.5 – 4.7 years. The available data suggests a sudden increase in 1988 to 5.6 years where it remained relatively constant until 2000. Since then MAM has been more variable ranging from 4.9 – 6.1 years.

The WG noted that the general trend in MAM does not appear to follow the changes in population size as would be expected if it was responding to density dependent factors. The reason for the large increase in the late 1980s was not apparent. It was suggested that the timing of sampling be examined to determine if differential migration of mature and immature animals may be occurring. Also, it was noted that condition data are available for this population and a comparison with fecundity rates could be extremely useful in understanding the changes that have been observed.

4.3.4 Population assessment

Pup production

Photographic and visual aerial surveys to determine current pup production of Northwest Atlantic harp seals were conducted off Newfoundland and in the Gulf of St. Lawrence during March 2008 (Stenson *et al*, SEA 202). Surveys of 5 whelping concentrations were conducted between 1 and 16 March resulting in estimated pup production of 287,000 (SE=27,600, CV 9.6%) in the Southern Gulf and 176,800 (SE=22,800, CV=12.9%) in the Northern Gulf (rounding to the nearest hundred). A small concentration at the Front was estimated to contain 23,400 (SE=5,500, CV=23.5%) pups. Although they differed from the visual survey estimate, two photographic surveys of the Main concentration at the Front were very similar. Averaging these two estimates resulted in an estimated pup production of 1,142,985 (SE=104,284, CV=9%). Combining this estimate with those of other areas, resulted in an estimate of total pup production (rounded to the nearest hundred) in 2008 of 1,630,300 (SE=110,400, CV=6.8%). This is significantly higher than estimated previously and is inconsistent with previous predictions obtained from the harp seal population model. Incorporating reproductive rates obtained from annual samples (Stenson and Wells SEA 203) directly into the model accounts for some of the large increase in estimates of pup production (see below).

The survey method has evolved over the last three decades. Initial surveys were flown using a combination of visual and photographic surveys. The photographic surveys have been modified by using a motion compensation mechanism in 1994, and then using a digital camera in 2008. Improvements in image quality have meant that factors to correct for missed seals have declined as image quality has improved. Using two methods/platforms to estimate NW Atlantic harp seals provides a backup in case one method (the visual or the photographic) survey is not completed for any single herd. In 2008, 2 photographic estimates were approximately 60% higher than visual estimates for the same herd. Visual surveys of this patch were thought to be incomplete and results were not included in the final estimate. A comparison of the digital camera system used in 2008 and the film camera system used previously showed that, once corrected for reader errors, the estimates from the two systems were comparable.

Reconnaissance surveys to detect all seal concentrations begin in February in the southern gulf. They continue throughout the survey period to detect concentrations. At the Front (off the northeast Newfoundland coast) satellite beacons are also deployed to monitor herd drift. This minimizes double counting of the same herd. At times this drift may be as much as 1.8 km/h. Surveys are usually completed at about the same time, which is about the 15 March at the Front and 1 March in the southern Gulf. Monitoring to determine the stage of pupping is also carried out to correct for animals born after the survey is flown. Few scattered animals are seen outside of the concentrations, but surveys usually fly from suitable ice to suitable ice, or lies are extended beyond the last observations of seals to obtain complete coverage of seals in the area. During the visual surveys observers sit in the back, with a navigator in the front. Currently, these observers remain in the same seat, but to ease possible observer fatigue, observers could be rotated with the navigator in the front seat.

A population model was used to examine changes in the size of the Northwest Atlantic harp seal population between 1952 and 2010 (Hammill and Stenson, SEA 204). The model incorporated information on reproductive rates, reported removals, estimates of non-reported removals and losses through bycatch in other fisheries to determine the population trajectory. The model was fit to eleven estimates of pup production beginning in 1952. The model was also fit to age specific reproductive rates that were smoothed from the annual estimates. However, this model did not fit the unusually high 2008 pup production estimate very well. This high pup production appears to be due to relatively high reproductive rates observed in the same year. This is in contrast to a general trend towards a decline in reproductive rates, as pup production has increased suggesting that the dynamics of this population are being mediated by density-dependent changes. Incorporating the annual pregnancy rates, whenever possible, improved the model fit.

Under the assumption that the population is continuing to grow exponentially, the total population in 2008 was estimated to be 8.0 million (95% CI =6.8-9.3 million) animals, increasing to 9.1 million (95% CI=7.5 to 10.7 million) animals in 2010. Under the assumption that density-dependent population growth is occurring and the population is nearing carrying capacity (K=12 million), the population in 2008 was 8.1 million (95% CI=7.3-8.9 million animals) increasing to 8.6 million (95% CI=7.8 to 9.4 million) animals in 2010.

The ice-related early mortality factor operates across all of the population although in most years it has been associated with high mortality in the southern Gulf. Mortality in recent years has affected both components of this population. This factor is currently based upon a qualitative assessment of the conditions. It was noted that as an internal multiplier, the exact value may not be as critical as the relative level.

The age specific pregnancy rates used in the forward projections will have a major impact on the population trajectory. The current approach uses the rate from the last year of the fitted model and projects this forward as a constant. The current model probably under-estimates the uncertainty associated with pregnancy rates in forward projections. Bootstrapping the reproductive rates from the past and using these in forward projections may be one approach to address the uncertainty. However, it is not clear whether one should bootstrap from the whole dataset or, for example the last 5 years reflect most recent conditions. Another possibility would be to add a density dependent component to the reproductive rates used in the projections.

Hammill and Stenson (SEA 208) present a model to estimate the population size of Northwest Atlantic harp seals prior to the beginning of the commercial hunt. Reconstructing historical population size provides useful information for management and conservation by providing an indication of abundance prior to exploitation. When combined with environmental variables, such estimates can also provide insights into how a species may respond to climate change. Harp seals have been commercially exploited since the early 1700s although significant catches did not begin until early in the 19th century. Catch data from historical records and recent harvests were incorporated into a surplus production model (Pella-Tomlinson) to reconstruct the dynamics of this population to the late 18th Century. Model runs estimated an initial population of 10.8 million (SE=196,000) animals. Estimates of population size were negatively correlated with catches and positively correlated with the winter North Atlantic Oscillation (NAO) index lagged by several years.

Although changes in the NAO have been correlated with ice extent in the northwest Atlantic, it was noted that it will also have an effect on harp and hooded seal prey resources, even if only indirectly. For example, the NAO directly affects phytoplankton or zooplankton abundance and/or distribution with cascade impacts on higher level predators. NAO indices only extend back to 1864. The WG noted that air temperature might be another proxy that could be used, and for which there may be a times series of data that extends further back in time.

5 Evaluation of how a projected increase in the total population of Northwest Atlantic harp seals might effect the proportion of animals summering in Greenland

There are no data on harp seal abundance in west Greenland. Catch statistics from an unrestricted seal hunt, are assumed to reflect the abundance along the Greenland coast and show a very strong correlation with population size through 2000 and explain more than 90% of the variation in the catch numbers. The correlation suggests that an increasingly larger number of the seals migrated to Greenland as the population increased. This relationship failed after 2000 when catches dropped, despite a continued increase in the population. The hunting effort has probably dropped somewhat in certain parts of Greenland since 2000, but it is also the general belief among hunters, that the number of harp seals has dropped considerably in Southwest Greenland (south of 67°N). This change in abundance coincide with a significant decrease in sea ice extend in the area between Canada and Greenland. Decreasing sea ice may affect their migratory pattern and their seasonal abundance in certain areas.

The data show that fairly precise predictions of seal abundance (catch numbers in Greenland) could have been calculated from the population size alone in the years up to 2000. After 2000, however, additional variables (e.g., changed sea ice extent) may have changed the distribution and local abundance of harps in Greenland waters. However, it is possible that changes in hunting effort during the latest decade may have contributed to the appearance of decline in abundance.

New estimates of abundance need to be developed to discriminate between actual and perceived changes in abundance. A time-series of surveys on seal abundance in Greenland waters would be a possibility. Seals will have to be surveyed at various times a year for a number of years. Such a model will, however, not be reliable before the time-series with the new variables is longer and include years with changing trends. Furthermore, it is possible (likely) that new variables become important as the population grow. The population is believed to approach carrying capacity and this is normally associated with new factors becoming important for a continued growth of the population. It is therefore uncertain whether the distribution of the seals in the years to come is predictable based on hind-cast analysis. Such analyses will, however, be important to describe how distribution patterns change as the population and the environment change.

Alternatively, a proxy of relative seal abundance (does abundance increase or decrease) might be found by selecting catch data from settlements where changes in hunting effort are likely to have been relatively small.

Ultimately, historically the abundance of seals in Greenland waters was positively associated with increases in the harp seal population. Since 2000, it appears that ecological and hydrographical changes may have changed this relationship, and possibly led to decreases in harp seals there. However, there are insufficient data available at this time to adequately analyze the latter.

6 Hooded seals (*Cystophora cristata*)

6.1 The Greenland Sea Stock

6.1.1 Information on recent catches and regulatory measures

Concerns over low pup production estimates resulted in a recommendation from ICES that no harvest of Greenland Sea hooded seals should be permitted, with the exception of catches for scientific purposes, from 2007 on (ICES 2006). This advice was immediately implemented. Total catches for scientific purposes (all taken by Norway) in 2010 and 2011 were 178 (including 14 pups) and 19 (including 15 pups), respectively (Haug & Zabavnikov, SEA 195).

Available data on fertility rate and maturity for the Greenland Sea stock of hooded seals are from 1956-1994. Updated information has, therefore, been required for some time. In 2007-2008, material for a broader project including both assessment of reproduction, contaminant loads and general health status of Greenland Sea hooded seals were collected from 85 animals. The scientific take of 178 animals, performed in a dedicated survey in the Greenland Sea in July 2010, were taken to supplement these samples. All new material from Greenland Sea hooded seals are now analyzed and compared with available historical material.

6.1.2 Current research

No new information.

6.1.3 Biological parameters

Frie (SEA 194) presented analyses of new and historical reproductive data for Greenland Sea hooded seals. Based on new reproductive samples collected in moulting patches off Northeast Greenland in July 2008 and July 2010, mean age at maturity was estimated at 3.7 (CI=0.4) years, which is considerably lower than the previous estimate of 4.6 years based on Russian moulting patch samples for the period 1990-94 used in previous models. In contrast, proportion based estimates of mean age at primiparity (MAP(P)) were similar for the 2008-10 and the 1991-94 data sets (5.5 years and 5.8 years, respectively) and a common MAP(P) of 5.7 years could be fitted. There were also no indications of consistent trends in frequency based estimates of mean age at primiparity based on both moulting and breeding patch data collected over the period 1958-2010. The most recent estimate of MAM(P) is based on samples collected in July and it is possible that the low estimate of MAM(P) is due to late ovulations in nulliparous females. A similar pattern has been found for Northwest Atlantic hooded seals, which also indicate that these late ovulations do not appear to result in successful pregnancies. The WG therefore agreed that parity curves are more appropriate for modeling of hooded seal population dynamics than maturity curves.

6.1.4 Population assessments

Øigård *et al*. (SEA 199) presented model-based assessments of the Greenland Sea hooded seals. The population model used to assess the abundance is an age-structured population dynamics model, using historical catch data and estimates of pup production in order to estimate the current total population. The model is similar to the model assessing the abundance of the Barents Sea / White Sea harp seal population (Øigård *et al*. SEA 197), and has been modified to incorporate historical maturity curves and historical pregnancy rates. The historical data on pregnancy rates that are available are unreliable. Hence, the model was run for a range of pregnancy rates, in addition to a run using the original model assuming constant reproductive data. Figure 3 show that all model runs indicate a population currently well below N_{30} (30% of largest observed population size). Following the Precautionary harvest strategy previously developed by WGHARP (see ICES2005, 2008), the implication of this is no current catches from the population.

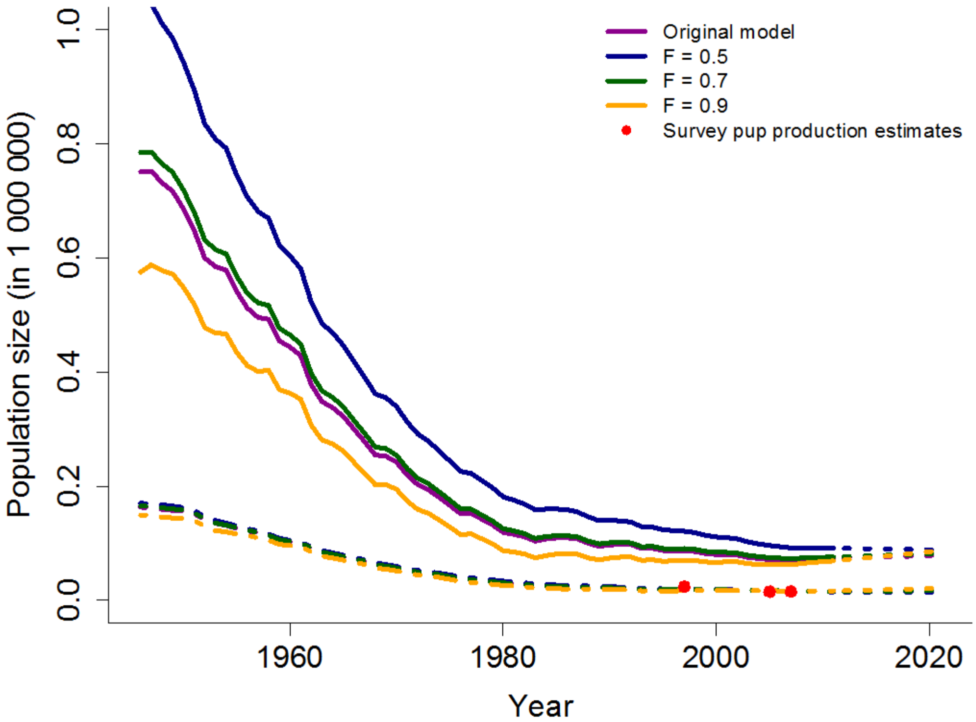

Figure 3. Greenland Sea hooded seals: Estimated model trajectories for various model scenarios. Full lines show 1+ abundance, dashed-dotted lines show pup abundances, and dashed lines show model predictions. Red dots are results from aerial pup production estimations.

6.2 The Northwest Atlantic Stock

6.2.1 Information on recent catches and regulatory measures

Under the Canadian Atlantic Seal Management Strategy (Hammill and Stenson 2007, 2009b), Northwest Atlantic hooded seals are considered to be data poor with the TAC set by considering a PBR approach. Prior to 2007, the TAC for hooded seals was set at 10,000 (Annex 8 Table 4). As a result of new data on the status of the population (Hammill and Stenson 2006) the quota was reduced to 8,200 in 2007 where it has remained. 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 (revised from 18), respectively. No hooded seals were reported taken in 2010 and preliminary estimates for 2011 indicate that only 1 hood has been taken.

Northwest Atlantic hooded seals are caught by hunters along the Greenland west coast and in their moulting area off Southeast Greenland. The reported catch has declined during the last 4 years with data available (2006-2009) from 4744 to 1982. The 2009 catch was the lowest catch since 1962.

6.2.2 Current research

Canada is continuing research on diets, reproductive rates and growth and condition. Canadian and Greenland scientists are continuing a study of the movements and diving behaviour of newly moulted hooded seals that provides data on habitat use. The animals are also acting as oceanographic samplers, collecting data on sea temperature and salinity.

6.2.3 Biological parameters

Frie *et al* (In review) presented results from joint analyses of Norwegian and Canadian reproductive data from Northwest Atlantic hooded seals collected between 1956 and 2010. For moulting patch samples collected in 1956-60, 1970-72 and 1978, mean age of maturity (MAM[P]) ranged from 3.2-3.3 years for June samples and 2.6-2.8 years for July samples. The effect of sampling month on MAM[P] was statistically significant. In contrast, estimates of Mean Age of Primiparity (MAP) did not differ between months and a common value of 3.9±0.04(CI) could be fitted to all moulting patch samples. Frequency based estimates of MAP based on a cut-off age of 7 years (MAP[7]) ranged from 4.2-4.4 years over the period 1970-1978 and then showed a moderate, but statistically significant, increase to 4.9 years in 1979. MAP [7] remained at this level in 1983-87 and 1989-95, whereas a further increase to 6.1 years was seen for the 1989-95 data, when using a cut-off age of 10 years. The overall proportion of older females (8+ years) with corpus albicans from pregnancies prior to the year of capture (P_{mult}) was stable at 91-98% over the period 1970-1987. P_{mult} decreased significantly to 79% for the period 1989-95 and 65% for 1996-2006 indicating a decline in adult pregnancy rates. Late term pregnancy rates for the period 1990-2006 were estimated at 69%. The most recent population models for NWA hooded seals are based on a natality rate of 95% and a maturity ogive with a MAM of 3.8 years. Effects of the observed variability in reproductive rates on population dynamics thus need to be explored.

7 Response to requests for advice on good environmental indicators from MSFDSG and SIASM

At the request of the Marine Strategy Directive Framework Steering Group (MSFDSG) and the Strategic Initiative on Area Based Science and Management (SIASM), the WGHARP identified and described the work streams of relevance to the European Commission's eleven descriptors with particular emphasis on linkages that between living marine resources (rather than fish stocks alone) and ecosystem/environmental monitoring and assessments.

Response to the MSFDSG request

The WG noted that that many of the principles identified in the European Commission's request for advice on the Descriptors should be extended to all upper trophic level marine species, including harp and hooded seals. Other marine taxa including other marine mammals, marine birds and marine turtles should also be considered as part of this exercise. An almost singular advantage of harp and hooded seals is that their population abundance, catch history, distribution, condition (including life history parameters), and ecological relationships are better understood than most other North Atlantic Ocean upper trophic level taxa. Similar data are also available for a few other species (e.g., United Kingdom grey seals, Baltic Sea/North Sea harbour seals). As key components of their ecosystems, it is important to consider these species, particularly because they can provide excellent indicators of ecosystem status.

Descriptor 1: *Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climate conditions.*

Species descriptors

At the individual species or population level there are considerable data available for harp and hooded seals for each of the three species descriptors. Seasonal distribution is well understood based on surveys of whelping and moulting areas, and considerable tagging and tracking efforts. Harp seals are animals of the shelf, while hooded seals populate the shelf break. Both, however, may be found over deeper waters during their ice associated periods. Population size is estimated biennially by members of the WG, reviewed at the WGHARP meetings, and presented in the WG's reports. Considerable information is available on the condition of the populations (e.g. maturity ogives and age-specific fecundity), and population structure has been determined through genetic analyses.

With respect to identifying indicators of ecosystem health, a common indicator used for these taxa, is that they should continue to remain a functioning element of the ecosystem in which they reside. WGHARP has adopted this concept in its precautionary approach to management advice by striving to maintain populations above N_{70}. The various population condition indices (e.g., population size, pup production, fecundity, physical condition) collected by the WG also provide important measures that can be used to evaluate health of the population, and, by inference, of the ecosystem. With respect to distribution, the WG considers that the maintenance of the current pattern of whelping patches should be maintained, though changes in abiotic conditions (loss of sea ice due to climate change) may make this difficult to achieve. Distribution outside of the whelping period will also provide indicators of ecosystem because of the predator-prey coupling that drives seal distribution.

Habitat descriptors

Specific abiotic and biotic habitat requirements for the species have been identified. Seasonal sea-ice is required for whelping, moulting and occasional hauling-out at other times of the year. Biotic requirements consist of the prey resources required by the species. Though specific prey have been identified as important in the diet, these prey will change spatially, seasonally, and annually in part driven by changes in the prey's availability. Thus, continuing information is required both from seal diets and prey resource surveys to evaluate these relationships. There is a particular need for data on non-commercial prey species.

Again, with respect to ecosystem status, it is the available abiotic and biotic habitat that will drive seal distribution. Thus, a reasonable measure of system status would be the degree to which habitat changes affect the distribution of seals, and efforts should be made to minimize habitat changes lead to redistribution of seal populations.

Ecosystem descriptors

Considerable research to date suggests that predator populations as large as the current North Atlantic harp seal population have a significant role in structuring ecosystems. There are numerous efforts extant that attempt to integrate marine mammal predation into ecosystem models; most of these suffer from a lack of specific information on predator populations and diets. However, harp and hooded seals are well enough understood that models incorporating their predation (e.g., the Canadian harp seal- Atlantic cod models) are likely to approach reality, rather than be purely conceptual (e.g., most EcoPath models). These impacts are likely to vary spatially, seasonally, annually, and over even longer periods.

The single best descriptor, and perhaps the goal for all ecosystem based management efforts with respect to seals, is that management efforts should continue to maintain harp and hooded seals as a functioning element of their respective ecosystems.

Descriptor 2: Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem.

Not applicable to this WG.

Descriptor 3: Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.

Although seals are not commercially exploited within the EU, both harp and hooded seals are taken by a number of ICES member countries. Since the descriptors have been identified with finfish in mind, many of the metrics identified in descriptor 3.1 are not appropriate for seals, although there are equivalents that have been developed and applied by WGHARP to harp and hooded seals. These include critical reference limits and precautionary reference limits (PRL), as well as the harvest control rules currently in place to maintain population above PRL.

Section for 3.2 suggests the use of SSB. This indictor is not appropriate for marine mammals. However, WGHARP does have measures of reproductive capacity for harp and hooded seals including maturity ogives and age-specific fecundity rates. Multiple estimates are available from all populations and are regularly monitored.

Population, age and size distribution (section 3.3) are also available for harp and hooded seals based on periodic surveys of pup production, and well developed age structured models. Size at age and sexual maturity data are also available for these species.

Descriptor 4: *All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.*

Many marine mammals, particularly species such as harp, hood and grey seals are top predators and key tropic species. This is a result of their high abundance and multiple trophic links. Although it is not part of the usual remit of WGHARP, we have examined trophic issues for harp and hooded seals and members of the WG have extensive data on diets of these species. The group could further address this Descriptor in the future. The WG noted that it would be useful for ICES to include other top predators such as cetaceans and sea bird in these discussions.

WGHARP has examined a number of sources of human induced mortality, including bycatch and non-reported takes. Estimates of this mortality are explicitly included in the estimates of removals for the NW Atlantic harp seal population where they are considered to be significant sources of mortality. There is also considerable information related to bycatch of other marine mammals available from other ICES WG.

The WG noted that it is critical to improve our understanding of the abundance and factors affecting life history of key non-commercial species (e.g. zooplankton, squid) and other species lower down on the food web that are often important forage species.

Ship strikes have also been shown to kill pinnipeds (and cetaceans) although the level of this mortality is not well documented for all species. The development of offshore tidal turbines presents another potential source of disturbance and mortality (especially for seabirds) that should be examined.

Descriptor 5: *Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters.*

Not applicable to this WG.

Descriptor 6: *Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.*

Not applicable to this WG.

Descriptor 7: *Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.*

Changes in hydrographic conditions have a direct and indirect impact on harp and hooded seals. Because harp and hooded seals require ice to pup, nurse and rest, they are significantly impacted by changes in ice development and extent. Members of the WG incorporate ice conditions into population assessments, when appropriate. Hydrographic conditions will also affect distribution of key prey species at several trophic levels.

Descriptor 8: *Concentrations of contaminants are at levels not giving rise to pollution effects.*

Seals and other marine mammals are often used as indicators or ecosystem health with respect to contaminants. This is because as predators they effectively represent a summation or reservoir of contaminants across the ecosystem, and also because of the way they store lipids. They are especially good as indicators of new contaminants because of how contaminants are magnified (bioaccumulation) at higher trophic levels. For example, the usefulness of marine mammals as indicators was shown when studying fire retardants.

Data on contaminant levels are available for both harp and hooded seals, but are not reviewed as part of the remit for this WG. However, given the data that are held by the members of the group, it would be possible to review these data in the future.

There is little known about the impacts of contaminants on harp and hooded seals although there is some information on impacts on other seal species that may be applicable. A similar lack of knowledge exists for the impacts of oil on pinnipeds.

Descriptor 9: *Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards*

Marine mammals are known to concentrate contaminants as upper trophic level consumers. Humans consume seals, particularly harp, hooded and ringed seals, in northern communities. As such, contaminants present a health danger to humans. The acceptable levels of contaminants vary with jurisdiction and comparison between levels present and standards is the responsibility of the public health authorities. The effects of these contaminants on humans are poorly understood.

Contaminants also have an effect on the animals themselves by compromising their health and reproduction.

There have been studies on contaminants levels in native foods in the Arctic and studies are currently underway looking at levels in harp and hooded seals. These data can provide a proxy of, at the least, the levels of contaminants in an ecosystem.

Descriptor 10: *Properties and quantities of marine litter do not cause harm to the coastal and marine environment.*

Marine litter has not been previously considered within the discussions of WGHARP. However, marine debris is an important issue for upper trophic level species such as marine mammals, sea turtles, and sea birds because it can result in mortality due to entanglements or ingestion.

As a measure of good environmental status with respect to this descriptor, the number of seals with evidence of entanglement in fishing gear may provide a cost effective approach to measuring the relative amount of debris present in a marine system.

Descriptor 11: *Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.*

Marine mammals are adversely affected by increases in noise within their environment. There is considerable research on this issue although not on harp or hooded seals.

Response to the SIASM request

Most of the work conducted by WGHARP is carried out within a spatial (geographical and temporal) context. Our WG assess some of the most abundant, large predators in the north Atlantic. As key species within their ecosystems, understanding pinnipeds and how they are affected by change is critical for any Marine Spatial Planning activity.

The SIASM report identifies a number of spatial planning and data needs that can be supported by data available on harp and hooded seals. Recognizing that harp, and possible to a lesser extent hooded, seals are key species within their ecosystems, and that their primary habitats are the ice covered seas, continental shelves and slope edges, the WG can provide for these taxa many of the indicators required indicators including:

- Abundance
- Changes in reproductive parameters (fecundity, maturity)
- Change in growth rates and condition
- Changes in distribution
- Changes in diets

Data are also available on several of the other themes of information requested. Fisheries management regulations are presented in our reports. Maps of distribution, whelping (pupping) areas and major feeding areas are available within the working papers presented at the WG meetings. The management approach adopted by ICES for seals requires the maximum population size to be identified. This has been done for all populations.

Finally, WGHARP members suggest that ICES and its WGs are structured to provide advice that is easily incorporated into the policy or planning advice, therefore the WG does not understand the intent of statements within the report suggesting the contrary. WGHARP also felt that it was not the role of scientists to advocate for particular outcomes. It is the role of managers and stakeholders to identify clear objectives and questions, and for scientists to provide an analysis of the likely outcomes. Managers and stakeholders will then be able to make decisions based on the best available analyses. It is also the role of scientists to identify the uncertainty, but managers must take into account this uncertainty and its implications when making decisions.

8 Advice for ACOM and NAFO

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

9 Other business

Members of WGHARP unanimously recommended to ACOM that Dr. Mike Hammill, Canada, serve as Chair for the WG for the next three meetings. They also thanked the outgoing chair for his efforts over the past 5 years.

The next meeting is tentatively scheduled for the Russian Commonwealth (likely Murmansk) in August 2013.

10 Adoption of the report

The WG adopted the report on 19 August 2011, at the close of the meeting.

Annex 1: List of participants

Name	Address	Phone/Fax	Email
Richard Merrick (Chair)	National Marine Fisheries Services Northeast Fisheries Science Center 166 Water Street Woods Hole MA 02543-1026 United States	Phone 1 50 849 52291	richard.merrick@noaa.gov
Anne 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
Mike Hammill	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
Tore Haug	Institute of Marine Research Institute of Marine Research Tromsø P.O. Box 6404 N-9294 Tromsø Norway	Phone 47 776 09722	tore.haug@imr.no
Viktor Korzhev	Knipovich Polar Research Institute of Marine Fisheries and Oceanography 6 Knipovitch Street RU-183763 Murmansk Russian Federation	Phone 7 815 247 2469	korgev@pinro.ru
Tor Arne Øigård	Institute of Marine Research Tromsø P.O. Box 6404 N-9294 Tromsø Norway	Phone 47 776 097 30	tor.arne.oeigaard@imr.no
Dr Paddy Pomeroy	SMRU Administration Sea Mammal Research Unit Gatty Marine Laboratory University of St Andrews St Andrews, Fife, KY16 8LB UK	Phone 44 01334 463061	rpp6@st-and.ac.uk
Aqqalu Rosing-Asvid	Greenland Institute of Natural Resources, Box 570, 3900 Nuuk Greenland.	Phone +299 361247	aqro@natur.gl

Name	Address	Phone/Fax	Email
Dr Sophie Smout	SMRU Administration Sea Mammal Research Unit Gatty Marine Laboratory University of St Andrews St Andrews, Fife, KY16 8LB UK	Phone 44 01334 462629	scs10@st-and.ac.uk
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
Dr Dave Thompson	SMRU Administration Sea Mammal Research Unit Gatty Marine Laboratory University of St Andrews St Andrews, Fife, KY16 8LB UK	Phone 44 01334 462637	dt2@st-and.ac.uk
Vladimir Zabavnikov	Knipovich Polar Research Institute of Marine Fisheries and Oceanography 6 Knipovitch Street RU-183763 Murmansk Russian Federation	Phone 7 815 247 2572	ltei@pinro.ru

Annex 2: Agenda

Monday, 15 August

1:00pm to 1:30pm -- Introductory Comments (Merrick)

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

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

1. *Information on recent catches and regulatory measures*
2. *Current Research (SEA200, SEA209)*
3. *Biological parameters (SEA196)*
4. *Population assessments (SEA197, SEA206, SEA210)*
5. *Catch Options (SEA197, SEA210)*

5:30pm Break for Day

Tuesday, 16 August

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

6. *Continue Monday discussions*

Noon to 1:00pm – Lunch

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

7. *Information on recent catches and regulatory measures (SEA195)*
8. *Current Research*
9. *Biological parameters*
10. *Population assessments (SEA198)*
11. *Catch Options (SEA198)*

5:30pm Break for Day

Wednesday, 17 August

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

12. *Information on recent catches and regulatory measures (SEA201)*
13. *Current Research (SEA205, SEA209)*
14. *Biological parameters (SEA202, SEA203)*
15. *Population assessments (SEA203, SEA204)*

11:00am to Noon – Evaluate how a projected increase in the total population of NW Atlantic harp seals can might affect the proportion of animals summering in Greenland (SEA207)

Noon to 1:00pm – Lunch

1:00pm to 3:00pm -- Hooded Seals: Greenland Sea Stock

16. *Information on recent catches and regulatory measures (SEA195)*
17. *Current Research*
18. *Biological parameters (SEA194)*
19. *Population assessments (SEA199)*
20. *Catch Options (SEA199)*

3:00pm to 3:30pm —Hooded Seals: Northwest Atlantic Stock

21. *Information on recent catches and regulatory measures*
22. *Current Research*
23. *Biological parameters*
24. *Population assessments*
25. *Catch Options*

3:30pm to 5:30pm

26. *Continue modelling, report writing*

5:30pm Break for Day

Thursday, 18 August

9:00am to noon

27. *Identify elements of the WGs' work that may help determine status for the 11 Descriptors set out in the Commission Decision (available at http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:232:0014:0024:EN:PDF;*
28. *Provide views on what good environmental status (GES) might be for those descriptors, including methods that could be used to determine status.*
29. *Comment on the Report of the Workshop on the Science for area-based management: Coastal and Marine Spatial (http://www.ices.dk/reports/SSGHIE/2011/WKCMSP11.pdf)*
30. *Provide information that could be used in setting pressure indicators that would complement biodiversity indicators currently being developed by the Strategic Initiative on Biodiversity Advice and Science (SIBAS). Particular consideration should be given to assessing the impacts of very large renewable energy plans with a view to identifying/predicting potentially catastrophic outcomes.*
31. *Identify spatially resolved data, for e.g. spawning grounds, fishery activity, habitats, etc.*

Noon to 1:00pm – Lunch

1:00pm to 5:30pm –Plenary discussions

32. *Continue Morning discussions*

5:30pm – Break for Day

Friday, 19 August

9:00am to noon

33. *Continue Thursday discussion*

Noon to 1:00pm – Lunch

1:00pm to 5:30pm –Plenary discussions

34. *TOR for next meeting*
35. *Identify new chair*
36. *Other business*

5:30pm – 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 XXXX for 4-5 days during August 2013 to:

Review results of 2012-2013 surveys

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

Provide advice on other issues as requested

The 2013 meeting is proposed to be held in Russia.

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

Supporting Information

Priority:	High priority as a tool for the assessment and management of harp and hooded seal in the North Atlantic Ocean. WGHARP receives requests for advice from member countries through ACOM and/or NAFO Scientific Council, incuding recognition of the need for a precautionary approach to mangement of seal populations.
Scientific justification and relation to action plan:	Action Numbers 4.3 and 4.3 A number of North Atlantic nations currently harvest harp and hooded seal stocks, and there is a need for a relatively neutral forum for developing and vetting scientific advice on sustainable harvests of these stocks. The WGHARP provides this forum through the inclusion of ICES and NAFO member state scientists expert in pinniped biology and the quantiative techniques necessary for development of sound catch advice; members represent all harvesting nations as well as nations without seal harvests. The activities of WGHARP are particularly relevant to action plan goals 3 and 4
Resource requirements:	None beyond the contributions from member states
Participants:	The Group is normally attended by some 10-15 members and guests.
Secretariat facilities:	None
Financial:	None
Linkages to advisory committees:	WGHARP reports to ACOM and NAFO Sc.C.
Linkages to other committees or groups:	LRC, RMC, WGMME, WGNPBW.
Linkages to other organizations:	NOAA/NMFS, NAMMCO, Joint Norwegian-Russian Fisheries Committee. The work of this group is closely aligned with harp and hooded seal research and management programs conducted by the governments of Canada, Greenland, Norway, Russia, and the United States

Annex 4: Recommendations

Recommendation	Action By
Reanalyze and continue time series of reproductive rates and condition indices for White Sea/Barents Sea harps, and expand to other populations	**Summer 2013**
Explore alternative ways of projecting F in the preliminary model	**Summer 2013**
Information on the observed variability in reproductive rates need to be incorporated into the NWA hooded seal model	**Summer 2013**
Sample for condition, and F in same year as pup surveys	**All surveys**
Conduct pup surveys for WS/BS, Greenland Sea, and NWA harps in 2012	**Spring 2012**
Review methods for determining appropriate survey start time for WS/BS pup surveys	**Winter 2012**
Continue collection of information on prey species in WS/BS to associate with condition data	**Continuing**
Collect information on important noncommercial prey species (e.g., *Themisto spp.*)	**Continuing**
Obtain, analyze, and publish diet data for West Greenland harps to help evaluate reasons for changes in harp seal distribution there	
Conduct regular telemetry studies for NWA harps to evaluate response to ice loss	
Conduct satellite tagging of harp seals in the WS/BS in 2012 and beyond	**Spring 2012**

Annex 5: References

Number	Author	Title
SEA194	Frie, A. K.	An update on reproductive parameters of Greenland Sea hooded seals (*Cystophora cristata*)
SEA195	Haug, T. and Za-bavnikov, V.	Norwegian and Russian catches of harp and hooded seals in the northeast Atlantic in 2010 and 2011
SEA196	Øigård, T. A., Lindstrøm, U., Nilssen, K. T., and Haug, T.	Variations in body condition of Barents sea harp seals during April-May in 1992-2011
SEA197	Øigård, T. A., Haug, T., Lind-strøm, U., Frie, A. K., and Nilssen, K. T.	The 2011 abundance of harp seals (*Pagophilus groenlandicus*) in the Barents Sea / White Sea
SEA198	Øigård, T. A., Haug, T., Frie, A. K., and Nilssen, K. T.	The 2011 abundance of harp seals (*Pagophilus groenlandicus*) in the Greenland Sea
SEA199	Øigård, T. A., Haug, T., Frie, A. K., and Nilssen, K. T.	The 2011 abundance of hooded seals (*Cystophora cristata*) in the Greenland Sea
SEA200	Svetochev, V.	Seasonal distribution of the White Sea population harp seal (*Phoca groenlandica*)on the first year of life
SEA201	Stenson, G.	Total and allowable catches of harp and hooded seals in Canada
SEA202	Stenson G. B., Hammill, M. O. and Lawson, J. W.	Estimating 2008 pup production of Northwest Atlantic harp seals, *Pagophilus groenlandicus*
SEA203	Stenson, G. and Wells, N.	Current reproductive and maturity rates of Northwest Atlantic harp seals, (*Pagophilus groenlandicus*)
SEA204	Hammill, M. O. and Stenson, G. B.	Estimating abundance of Northwest Atlantic harp seals assuming different levels of density dependence
SEA205	Hammill, M. O. , Stenson, G. B., and Kingsley, M.C.S.	Historical abundance of Northwest Atlantic harp seals (*Pagophilus groenlandicus*): influence of harvesting and climate
SEA206	Zabavnikov, V. B., and Shafikov, I. N.	Assessment of the White Sea/Barents Ssea harp seal population (*Phoca groenlandica*) pup production recent status
SEA207	Rosing-Asvid, A.	How does the size of the Northwest Atlantic harp seal population influence the proportion of seals summering in Greenland?

Number	Author	Title
SEA208	Hammill, M.O., and Stenson, G. B.	Some possible reasons for the decline in White Sea pup production
SEA209	Hammill, M.O., and Stenson, G. B	Living on the edge: Observations of Northwest Atlantic harp seals in 2010 and 2011
SEA210	Korzhev, V.A.	Abundance estimation of the White Sea harp seal population (*Phoca groenlandica*) by different models and harvesting strategy in 2012-2013

Other References

Author	Year	Citation
ADMB Project	2009	AD Model Builder: automatic differentiation model builder. Developed by David Fournier and freely available from admb-project.org.
DFO	2010	Canadian Atlantic seal management strategy. Canadian Science Advisory Secretariat Science Advisory Report 2010/089
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., Stenson,G.B.. and Haug,T.	In review	Long term trends in reproductive and demographic parameters of female Northwest Atlantic hooded seals Cystophora cristata (Erxleben,1777): Population responses to ecosystem change?. Canadian Journal of Zoology.
Nordøy, E.S., Folkow, L.P., Potelov, V., Prischemikhin, V. And Blix, A.S.	2008	Seasonal distribution and dive behaviour of harp seals (Pagophilus groenlandicus) of the White Sea – Barents Sea stock. Polar Biol. 31: 1119-1135.
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.
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.
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

Author	Year	Citation
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.
Kjellqwist, S. A., Haug, T., and Øritsland, T.	1995	Trends in age composition, growth and reproductive parameters of Barents Sea harp seals, Phoca groenlandica. ICES Journal of Marine Science, 52: 197–208.
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.
WGHARP	2006a	Report of the Joint ICES/NAFO Working Group on Harp and Hooded Seals, 30 August – 3 September, 2005, St. John's, Newfoundland, Canada. ICES CM 2006/ACFM. 44 Pp.
WGHARP	2006b	Report of the Working Group on ICES/NAFO Working Group on Harp and Hooded Seals (WGHARP), 12-16 June 2006, ICES Headquarters. ICES CM 2006/ACFM:32. 28 pp.
WGHARP	2008	Report of the Working Group on ICES/NAFO Working Group on Harp and Hooded Seals (WGHARP), 27-30 August, Tromso, Norway. ICES CM 2008/ACOM:17. 57 pp.
WGHARP	2009	Report of the Working Group on ICES/NAFO Working Group on Harp and Hooded Seals (WGHARP), 24-27 August,2009, Copenhagen, Denmark. ICES CM 2009/ACOM:17. 51 pp

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

Table 1. Catches of hooded seals in the Greenland Sea ("West Ice") from 1946 through 2011[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

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
1995	368	565	933	-	-	-	368	565	933
1996	575	236	811	-	-	-	575	236	811
1997	2765	169	2934	-	-	-	2765	169	2934
1998	5597	754	6351	-	-	-	5597	754	6351
1999	3525	921	4446	-	-	-	3525	921	4446
2000	1346	590	1936	-	-	-	1346	590	1936
2001	3129	691	3820	-	-	-	3129	691	3820
2002	6456	735	7191	-	-	-	6456	735	7191
2003	5206	89	5295	-	-	-	5206	89	5295
2004	4217	664	4881	-	-	-	4217	664	4881
2005	3633	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

[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"), 1946-2011[a,b]. Catches from 1995 onward includes catches under personal use licences. YOY refers to Young of Year. Catches from 1990-1996 were not assigned to age classes. With the exception of 1996, all were assumed to be 1+.

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

	Large Vessel Catches				Landsmen Catches[c]				Total Catches			
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	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	1	0	1	0	1	0	1

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

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

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

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

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

[f] Number of YOY estimated from reported illegal catches

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

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

Year	West Atlantic Population				NE	All Greenland
	West	KGH[b]	Southeast	Total		
2001	5010	-	1496	6506	8	6514
2002	3606	-	1189	4795	11	4806
2003	4351	-	1992	6343	10	6353
2004	4133	-	1690	5823	20	5843
2005	3092	-	1022	4114	14	4128
2006	4194	-	550	4744	3	4747
2007	2575	-	712	3287	7	3294
2008	2085	-	519	2604	2	2606
2009	1624	-	358	1982	1	1983

[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 2011[a]. Totals include catches for scientific purposes.

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

Year	Norwegian catches			Russian catches			Total catches		
	Pups	1 year and older	Total	pups	1 year and older	Total	Pups	1 year and older	Total
1996	5649	778	6427	-	-	-	5649	778	6427
1997	1962	199	2161	-	-	-	1962	199	2161
1998	1707	177	1884	-	-	-	1707	177	1884
1999	608	195	803	-	-	-	608	195	803
2000	6328	6015	12343	-	-	-	6328	6015	12343
2001	2267	725	2992	-	-	-	2267	725	2992
2002	1118	114	1232	-	-	-	1118	114	1232
2003	161	2116	2277				161	2116	2277
2004	8288	1607	9895				8288	1607	9895
2005	4680	2525	7205				4680	2525	7205
2006	2343	961	3304				2343	961	3304
2007	6188	1640	7828				6188	1640	7828
2008	744	519	1263				744	519	1263
2009	5177	2918	8035	-	-	-	5117	2918	8035
2010	2823	1855	4678	-	-	-	2823	1855	4678
2011	5361	4773	10134	-	-	-	5361	4773	10134

[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

[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]	98,459	190,914
2001	226,493	600[a]	85,428	312,521
2002	312,367	1,000	66,735	380,102
2003	289,512	1,000	66,149	356,661
2004	365,971	1,000	70,586	437,557
2005	323,826	1,000	91,696	416,522
2006	354,867	1,000	92,210	448,077
2007	224,745	1,000	82,836	308,581
2008	217,850	1,000	80,556	299,406
2009	76,668	1,000	71,046	148,714
2010	69,101	1,000	83,669[b]	153,770
2011	38,018	1,000	83,669[b]	122,687

[a] Rounded
[b] Average of catches 2005-2009

Table 4. Harp seal catches 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.

Year	Large Vessel Catch				Landsmen Catch				Total Catches			
	Pups	1+	Unk	Total	Pups	1+	Unk	Total	Pups	1+	Unk	Total
1946-50	108256	53763	0	162019	44724	11232	0	55956	152980	64995	0	217975
1951-55	184857	87576	0	272433	43542	10697	0	54239	228399	98273	0	326672
1956-50	175351	89617	0	264968	33227	7848	0	41075	208578	97466	0	306044
1961-65	171643	52776	0	224419	47450	13293	0	60743	219093	66069	0	285162
1966-70	194819	40444	0	235263	32524	11633	0	44157	227343	52077	0	279420
1971	169426	14343	0	183769	41153	6044	0	47197	210579	20387	0	230966
1972	104109	1646	0	105755	12701	11427	0	24128	116810	13073	0	129883
1973	63369	15081	0	78450	34966	10416	0	45382	98335	25497	0	123832
1974	85387	21828	0	107215	29438	10982	0	40420	114825	32810	0	147635
1975	109832	10992	0	120824	30806	22733	0	53539	140638	33725	0	174363
1976	93939	4576	0	98515	38146	28341	0	66487	132085	32917	0	165002
1977	92904	2048	0	94952	34078	26113	0	60191	126982	28161	0	155143
1978	63669	3523	0	67192	52521	42010	0	94531	116190	45533	0	161723
1979	96926	449	0	97375	35532	27634	0	63166	132458	28083	0	160541
1980	91577	1563	0	93140	40844	35542	0	76386	132421	37105	0	169526
1981[d]	89049	1211	0	90260	89345	22564	0	111909	178394	23775	0	202169
1982	100568	1655	0	102223	44706	19810	0	64516	145274	21465	0	166739
1983	9529	1021	0	10550	40529	6810	0	47339	50058	7831	0	57889
1984	95	549	0	644[e]	23827	7073	0	30900	23922	7622	0	31544
1985	0	1	0	1[e]	13334	5700	0	19034	13334	5701	0	19035
1986	0	0	0	0	21888	4046	0	25934	21888	4046	0	25934
1987	2671	90	0	2761	33657	10356	22	44035	36350	10446	0	46796
1988	0	0	0	0	66972	13493	13581	94046	66972	27074	0	94046
1989	1	231	0	232[e]	56345	5691	3036	65072	56346	8958	0	65304
1990	48	74	0	122[e]	34354	23725	1961	60040	34402	25760	0	60162
1991	3	20	0	23[e]	42379	5746	4440	52565	42382	10206	0	52588
1992	99	846	0	945[e]	43767	21520	2436	67723	43866	24802	0	68668
1993	8	111	0	119[e]	16393	9714	777	26884	16401	10602	0	27003
1994	43	152	0	195[e]	25180	34939	1065	61184	25223	36156	0	61379
1995	21	355	0	376[e]	33615	31306	470	65391	34106	31661	0	65767
1996	3	186	0	189[e]	184853	57864	0	242717	184856	58050	0	242906
1997	0	6	0	6[e]	220476	43728	0	264204	220476	43734	0	264210
1998	7	547	0	554[e]	0	0	282070	282070	7	547	282070	282624
1999	26	25	0	51[e]	221001	6769	16782	244552	221027	6794	16782	244603
2000	16	450	0	466[e]	85035	6567	0	91602	85485	6583	0	92068
2001	0	0	0	0	214754	11739	0	226493	214754	11739	0	226493
2002	0	0	0	0	297764	14603	0	312367	297764	14603	0	312367
2003	0	0	0	0	280174	9338	0	289512	280174	9338	0	289512
2004	0	0	0	0	353553	12418	0	365971	353553	12418	0	365971
2005[f]	0	0	0	0	319127	4699	0	323820	319127	4699	0	323820
2006	0	0	0	0	346426	8441	0	354867	346426	811	0	354867
2007	0	0	0	0	221488	3257	0	224745	221488	3257	0	224745
2008	0	0	0	0	217565	285	0	217850	217565	285	0	217850
2009	0	0	0	0	76668	0	0	76668	76668	0	0	76668
2010	0	0	0	0	68654	487	0	69101	68654	487	0	69101
2011	0	0	0	0	37886	132	0	38018	37886	132	0	38018

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

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

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

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

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

Table 5. Catches of harp seals in Greenland, 1954–1987 (List-of-Game), and 1993–2009 (Piniarneq), and % adultsa according to the hunters' reports.

Year	West Greenland		South East Greenland		North East Greenland		All
	Catch num-	%	Catch num-	%	Catch num-	%	Catch num-
1954	18,912		475		32		19,419
1955	15,445		178		45		15,668
1956	10,883		180		5		11,068
1957	12,817		133		40		12,990
1958	16,705		360		30		17,095
1959	8,844		168		7		9,019
1960	15,979		350		16		16,345
1961	11,886		219		13		12,118
1962	8,394		211		10		8,615
1963	10,003	21	215	28	20	50	10,238
1964	9,140	26	125	40	7	86	9,272
1965	9,251	25	76	65	2	100	9,329
1966	7,029	29	55	55	6		7,090
1967	4,215	38	54	35	10		4,279
1968	7,026	30	180	47	4		7,210
1969	6,383	21	110	62	9		6,502
1970	6,178	26	182	70	15	100	6,375
1971	5,540	24	63	48	5		5,608
1972	5,952	16	84	48	6	100	6,042
1973	9,162	19	100	20	38	79	9,300
1974	7,073	21	144	29	27	95	7,244
1975	5,953	13	125	20	68	72	6,146
1976	7,787	12	260	48	27	55	8,074
1977	9,938	15	72	16	21	81	10,031
1978	10,540	16	408	14	30	36	10,978
1979	12,774	20	171	19	18	25	12,963
1980	12,270	17	308	14	45		12,623
1981	13,605	21	427	15	49		14,081
1982	17,244	16	267	20	50	60	17,561
1983	18,739	19	357	56	57	30	19,153
1984	17,667	16	525	19	61		18,253
1985	18,445	2	534	0	56	52	19,035
1986	13,932[b]	10	533[b]	18	37[b]	65	14,502[b]
1987	16,053[b]	21	1060[b]	24	15[b]	60	17,128[b]
1988-	For 1988 to 1992 comparable catch statistics are not available.						
1993	55,792	50	1,054	30	40	93	56,886
1994	56,941	50	864	30	88	65	57,893
1995	62,296	53	906	36	61	52	63,263
1996	73,287	52	1,320	35	69	59	74,676
1997	68,241	49	1,149	28	201	58	69,591
1998	80,437	51	1,670	30	110	73	82,217
1999	91,321	50	3,592	12	104	65	95,017
2000	97,229	44	2,459	15	113	76	99,801
2001	84,165	42	2,525	18	73	68	86,763
2002	65,810	46	1,849	19	66	86	67,725
2003	64,735	44	2,828	24	44	77	67,607
2004	69,273	41	2,625	27	207	29	72,105
2005	90,308	35	2,775	18	38	58	93,121
2006	91,191	33	2,038	16	89	78	93,318
2007	81,485	32	2,702	21	85	53	84,272
2008	78,747	32	3,617	15	50	90	82,414
2009	70,411	33	1,269	9	36	44	71,716

[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 1952-2011.

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

Year	Reported	Bycatch	Struck and Lost	Total
2003	356,661	5,367	91,233	453,261
2004	437,557	12,330[a]	102,612	552,498
2005	416,522	12,330[a]	114,191	543,043
2006	448,077	12,330[a]	112,254	572,661
2007	308,581	12,330[a]	98,750	419,661
2008	299,406	12,330[a]	93,292	405,028
2009	148,714	12330[a]	76,081	237,125
2010	153,770	12,330[a]	88,769	254,869
2011	122,687	12,330[a]	86,795	221,812

[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"), 1985–2011.

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	
2007-11[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

[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"), 1979–2011.[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

[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, 1961–2011.

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	TAC increased to 400,000

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

Year	Management Measure
1964	Hunting of hooded seals banned in the Gulf area (below 50oN), effective 1965.
1966	ICNAF assumed responsibility for management advice for northwest Atlantic.
1968	Open season defined (12 March–15 April).
1974–1975	TAC set at 15,000 for Canadian waters. Opening and closing dates set (20 March–24 April).
1976	TAC held at 15,000 for Canadian waters. Opening delayed to 22 March. Shooting banned between 23:00 and 10:00 GMT from opening until 31 March and between 24:00 and 09:00 GMT thereafter (to limit loss of wounded animals).
1977	TAC maintained at 15,000 for Canadian waters. Shooting of animals in water prohibited (to reduce loss due to sinking). Number of adult females limited to 10% of total catch.
1978	TAC remained at 15,000 for Canadian waters. 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	Additional requirements implemented to ensure humane killing methods are used
2010	No change
2011	No change