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Executive summary

The ICES/NAFO Working Group on Harp and Hooded Seals (WGHARP) met during 12-15 June at the ICES Directorate in Copenhagen, Denmark to consider recent research and to provide catch advice on the North Atlantic stocks of hooded seals (*Cystophora cristata*). In attendance were thirteen scientists representing Canada, Denmark, Norway, United Kingdom, and United States. During 12-14 June, the WG received presentations related to stock identity and distribution, catch (mortality) estimates, abundance estimates, biological parameters, and ecological relationships. On 14-15 June, the WG reviewed Canadian stock assessments for the Northwest Atlantic stock. It also assessed the Northeast Atlantic (Greenland Sea) stock and provide catch options in response to a request from Norway.

At the current meeting, WGHARP also reviewed the data available on Greenland Sea hooded seals. The most recent survey of pup production was carried out in March 2005 and resulted in an estimate of 15,200 (SE = 3,790, CV = 24.9%). This estimate is considerably lower than the estimate obtained with similar methodology in the Greenland Sea in 1997. Incorporating these estimates into a population model indicates that Greenland Sea hooded seals underwent a substantial decrease in population abundance from the late 1940s and up to the early 1980s. In the most recent two decades, the stock appears to have stabilized at a low level, but the current trajectory is uncertain. Although the model is sensitive to assumption of mortality, all model runs gave very similar results for the current abundance. The 2005 abundance is estimated to be 71,400 (std 16,823) 1+ seals and 16,900 (std 3,418) young of the year.

At its 2003 meeting (ICES CM 2004 / ACFM:06), WGHARP presented an outline of an approach for incorporating the Precautionary Approach to the management of harp and hooded seals. Additional clarification of this approach was provided at the 2005 meeting of WGHARP (ICES CM 2006/ACFM:06). Although a survey was carried out in 2005, the Working Group concluded that this population should still be considered as 'Data Poor'. Under its Precautionary Approach to the management of harp and hooded seals WGHARP considers that all harvesting should be terminated if stock size falls below N_{lim}. Using the best estimate available for N_{max} from the model runs conducted at this meeting, it appears that the current stock size of Greenland Sea hooded seals is well below 30% of N_{max}. As such, WGHARP recommends that no harvest be allowed for Greenland Sea hooded seals at this time because the stock size is below N_{lim}. This follows the Precautionary harvest strategy developed by WGHARP in its 2003 and 2005 meetings.

Surveys of all three whelping areas in the Northwest Atlantic were also carried out in 2005. Pup production at the Front was estimated to be 107,013 (SE = 7,558, CV = 7.1%) while 6,620 (SE = 1,700, CV = 25.8%) pups were estimated to have been born in the Gulf and 3,346 (SE = 2,237, CV = 66.8%) in Davis Strait. Total pup production in the northwest Atlantic was 116,900 (SE = 7,918, CV = 6.8%). Comparison with previous estimates suggests that pup production may have increased since the mid 1980s but considerable uncertainty about the relationship among whelping areas remains. Fitting to pup production estimates from all herds and making assumptions about numbers of hooded seals in the Davis Strait herd for years when this area was not included in the survey program, results in an estimate of total population in 2005 of 592,100 (SE=94,800; 95% C.I.= 404,400-779,800). Using only pup production estimates from the Front the total population was estimated to be 537,100 (SE=122,500; 95% C.I. 294,600-779,600). Under the Precautionary Approach identified for the management of seal by WGHARP, Northwest Atlantic hooded seals are considered 'Data Poor' because of the limited number of recent surveys, and the quality of data on reproductive rates and age structure of the harvest. Though Data Poor, the stock appears to be above Nlim (defined as 30% of Nmax).

1 Opening of the meeting

The Working Group, chaired by R. Merrick, and comprised of scientists from Canada, Denmark, Norway, United Kingdom, and USA met at the ICES Directorate in Copenhagen, Denmark on 12-14 June 2006. A list of participations is provided in Annex 1.

The meeting was in two parts. During 12-14 June, members of the WG conducted a review of previous and ongoing hooded seal (*Cystophora cristata*) research. The WG continued its deliberations on 14-15 June with a review of the recent data on the status of the Northwest Atlantic hooded seal population and a reassessment of the Greenland Sea hooded seal stock.

2 Adoption of the agenda

The agenda as adopted for the meeting is shown in Annex 2.

3 Terms of reference

In June 2005 the Norwegian Royal Ministry of Fisheries and Coastal Affairs requested ICES to assess the status of the stocks of harp and hooded seals in the Greenland Sea and harp seals in the White Sea/Barents Sea. ICES was specifically requested to assess the impact on these stocks of an annual harvest at:

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

The advice related to the harp seal populations in the Greenland Sea and White Sea/Barents Sea was provided during our last meeting (ICES CM 2006 / ACFM:06). However, at the 2005 meeting of the WG, it was noted that a number of studies related to hooded seals will be competed in the coming year. These data will likely lead to a significant improvement in the ability of the WG to assess the status of and consequences of different catch scenarios on North Atlantic hooded seal stocks (e.g., the Greenland Sea stock). Therefore, the WG recommended to the ICES Advisory Committee on Fishery Management (ACFM) that all available data relevant to the charge of the WG be analyzed and presented at the WG's June 2006 meeting. To facilitate these discussions, the WG also recommended that the meeting include a workshop devoted to current research on hooded seals. Themes of the workshop included:

- Stock identity, distribution and migration
- Catch (mortality) estimates
- Abundance estimates
- Biological parameters
- Ecological relationships

The meeting concluded with two additional days devoted to reviewing the status of hooded seal stocks in the Northwest Atlantic Ocean and in the Greenland Sea. This allowed the Working Group to provide quota advice to ACFM on the Greenland Sea stock in response to the request received previously.

4 Status of hooded seals (*Cystophora cristata*)

4.1 Stock Identify, Distribution and Migration

Coltman reported on results of a study of the two putative populations of hooded seals (*Cystophora cristata*) that occur in the Northwest Atlantic (Coltman et al., this meeting, WP SEA 158). The Greenland Sea population pup and breed on the pack ice near Jan Mayen ('West Ice') while the Northwest Atlantic population is thought to breed in the Davis Strait, in the Gulf of St. Lawrence (the 'Gulf'), and off southern Labrador or northeast Newfoundland (the 'Front'). Microsatellite profiling of 300 individuals using 13 loci and mitochondrial DNA sequencing of the control region of 78 individuals was carried out to test for genetic differentiation between these four breeding herds. No significant genetic differences were found between breeding areas, nor was there evidence for cryptic or higher level genetic structure in this species. The Greenland Sea breeding herd was genetically most distant from the Northwest Atlantic breeding areas; however the differences were statistically non-significant. These data, therefore, suggest that the world's hooded seals comprise a single, panmictic genetic population.

Stenson (this meeting, SEA 157) presented a review of the results of tagging hooded seals in Davis Strait and off Newfoundland since the early 1980s. Previous reviews of tag returns indicated that there is considerable overlap among seals from the three Northwest Atlantic whelping areas in Greenland and at the Denmark Strait moulting grounds, but little overlap between hooded seals from the Northwest and Northeast Atlantic. Since 1983, a total of 3,435 seals were tagged as pups off Newfoundland (1983-85, 1994), in Davis Strait (1984), and in the Gulf (1986). Of the 40 tags returned up to 2006, 26 came from western or southeastern Greenland, 11 from Canada, and 3 from northeastern Greenland. The northeast Greenland tags were returned from adults captured during May (i.e. between breeding and moulting). This indicates that there is some overlap between these two populations during the non-breeding period, although the amount of interbreeding between them is unknown.

Øien presented a paper from the 1983 Hooded Seal Workshop on the frequency of supernumerary teeth in West Ice and Northwest Atlantic hooded seal stocks (Bergflodt and Oritsland, SW-83/Doc 113). Frequencies of supernumerary teeth show no significant differences between sexes among breeding hooded seals at Newfoundland, nor between combined samples of both sexes from breeding hoods at Newfoundland and moulting hoods in the Denmark Strait. However, a highly significant difference was found when pooled samples from Newfoundland and the Denmark Strait were compared to combined samples from the West Ice. This difference is taken to indicate a possible genetic separation of hooded seals in the West Ice from hooded seals in the Northwest Atlantic. A number of caveats to this interpretation were also presented and discussed

Russian data were presented to further describe the distribution of hooded seal whelping patches during 1955-94 (Svetochev and Bondarev, this meeting, SEA 149). These data were collected from vessels and planes searching for commercial aggregations of hooded seals in the Greenland Sea from March until July. The grounds of hooded seals were widespread, depend on character of ice conditions, but were generally distributed to the east of Jan Mayen mainly on an ice edge between 70E 00' and 74E 00' N.

Data on the pelagic distribution of Greenland Sea hooded seals presented in Folkow et al (1996) were reviewed. Nineteen hooded seals were tagged with satellite-linked platform terminal transmitters (PTT) on the sea ice near Jan Mayen. Fifteen were instrumented after completion of the moult, in July 1992 (five males, ten females) and four during breeding in March 1993 (four females) Sixteen of the seals were tagged with Satellite-Linked Time-Depth-Recorders (SLTDR), yielding location, dive depth and dive duration data. The average

longevity of all PTTs was 199 ±84 days (n = 19; range: 43-340 days), and they yielded 12,834 location fixes. Between tagging in July 1992 and pupping in March 1993, two seals remained in or near the ice off the east coast of Greenland for most of the tracking period. However, most of the seals made one or several trips away from the ice edge, mostly, to distant waters. These excursions had an average duration of 47 ±22 days (n = 46; range: 4-99 days). Eight seals travelled to waters off the Faeroe Islands, three to the continental shelf break south of Bear Island, and three to the Irminger Sea southwest of Iceland. Eleven seals were tracked in the period between breeding (March/April) and moulting (July). Several of these spent extended periods at sea west of the British Isles, or in the Norwegian Sea.

Finally, new data on the distribution of hooded seals in the Northwest Atlantic was presented by Stenson (Stenson et al. this meeting, SEA 159). Twenty-eight adult hooded seals were equipped with satellite linked platform terminal transmitters during four trips to the whelping concentrations of the Gulf of St Lawrence, "the Gulf" and off the north-eastern coast of Newfoundland, the 'Front' during March from 1991 to 1994. Seals were tracked for 59 to 107 days, (ave=93.6 SD= 11.6d). Locations were obtained for an average of 87.8 % (SD=7.0%; range 33.3-97.8) of the days. Although there was individual variation, the movements of hooded seals between the breeding and moulting areas shared a distinct pattern. After breeding, seals moved to specific areas, the slope edges of the Laurentian Channel in the Gulf of St Lawrence, the Flemish Cap, the Grand Banks and/or the Reykjanes Ridge where they remained for an average of 6 weeks. By late May, animals had begun to move to southeast Greenland where they remained until the end of the transmission period as transmitters fell off during the annual moult in June.

Stenson also described a study currently underway to determine annual movements of hooded seals in the Northwest Atlantic. As part of a joint project between the Department of Fisheries and Oceans, Canada (NL and Quebec Regions) and the Greenland Institute of Natural Resources, over 20 newly moulted hooded seals have been caught off east Greenland during July 2004 and 2005. They have been tracked around the Greenland coast and into Baffin Bay where they remained until the winter. Mature seals then proceeded to the whelping areas at the Front or in the Gulf before returning to the moulting areas. The majority of immature hooded seals remained in Greenland waters throughout the year. A few of the animals spent time in areas that overlap with areas inhabited by seals from the Greenland Sea population. The study is continuing with additional deployments in July 2006.

4.2 Greenland Sea Hooded Seals

4.2.1 Recent catches and regulatory measures

Average annual catches in the early 1960s were approximately 47 000 individuals, whereas in the early 1980s the level had declined to c. 8 000 seals (Annex 6, Table 1. In the past 25 years, the average annual catch level has remained less than 5 000 animals (almost exclusively pups, se Figure 1) which is considerably lower than the TACs given for the period (Annex 7, Table 1). Catches in 2005 were well below the 5,600 animal TAC.

4.2.2 Current research

Data were provided by Haug on the feeding habits of hooded seals in the Greenland Sea (Haug et al., this meeting, SEA 147). Seals were collected for scientific purposes on expeditions conducted in the pack ice belt east of Greenland in September/October 1999, 2002 and 2003 (autumn), July/August in 2000 (summer), and February/March in 2001 and 2002 (winter). Results from analyses of stomach and intestinal contents revealed that the diet was comprised of relatively few prey taxa. The squid *Gonatus fabricii* and polar cod *Boreogadus saida* were particularly important, whereas capelin *Mallotus villosus*, and sand eels

Ammodytes spp contributed more occasionally. *G. fabricii* was the most important food item in autumn and winter, whereas the observed summer diet was more characterized by polar cod, however with important contribution also from *G. fabricii* and sand eels. The latter was observed on the hooded seal menu only during the summer period, while polar cod, which contributed importantly also during the autumn survey, was almost absent from the winter samples. During the latter survey, capelin also contributed to the hooded seal diet. Samples obtained in more coastal waters indicated a varied, fish based (polar cod, redfish *Sebasetes sp*., Greenland halibut *Reinhardtius hippoglossoides*) diet.

Wilkinson presented results of his research on the association between ice conditions/presence and the areas of hooded seal whelping (Wilkinson and Wadhams 2006). Whelping areas have been traditionally associated with area of ice known locally as the Odden, a tongue of consolidated pack ice to the north of Jan Mayen Island. However, in recent years the feature has not been present and as a result whelping has occurred in other areas, with unknown consequences.

Tryland summarized recent investigations of the incidence of Brucella-infections in wild-caught hooded seals caught between Svalbard and Greenland (North Atlantic Ocean; Greenland Sea) autumn 2002 (Tryland et al. 2005). All animals were apparently healthy. Bacteriology on tissue samples from ringed seals was negative, whereas Brucella sp. were recovered in tissues from 11 of the 29 hooded seals (38%), with the highest tissue prevalence in spleen (9/29) and lung lymph nodes (9/24). Anti-Brucella antibodies were detected in sera from 9 hooded seals (31%). The bacterial isolates all belonged to the genus Brucella according to classical biotyping and PCR analysis based on Insertion Sequence IS711, and were shown to be typical marine mammal strains, based on the occurrence of an IS711 element downstream of the bp26 gene. Their dependency on CO2 for growth, and the presence of one copy each of the omp2a and omp2b gene finally classified them as Brucella pinnipediae. Furthermore, all the hooded seal isolates showed an A+ M+ agglutination profile, which is different from the profile of reference seal strain 2/94 (harbour seal, *Phoca vitulina*). Thus, these results indicate that *B. pinnipediae* may contain different biovars. The present results suggest that infection with *B. pinnipediae* is enzootic in this population. Brucella-bacteria are known to cause abortions and sterility in terrestrial mammals. Due to the estimated decrease in pup production in the Greenland Sea population of hooded seals ("West-Ice"), WGHARP agreed that the potential impact of such infections on individual and population levels (reproductive disorders) should be further investigated. Because the hooded seal is commercially hunted and consumed in Norway, WGHARP also agreed that their zoonotic potential should be further studied.

Tranum-Jensen briefly presented the preliminary results of his study of the relationship between blubber thickness, bone mass, and buoyancy in pinnipeds. Briefly, his research suggests that as blubber thickness increases, bone mass increases perhaps to compensate for the positive buoyancy inherent in thicker blubber. Dr. Tranum-Jensen expects to complete this research in 2007-2008 and will present his results then.

4.2.3 Biological parameters

Frie presented information on mean age at maturity (MAM) and fertility rates of Greenland Sea hooded seals (Svetochev and Frie, this meeting SEA 162). Age at maturity was determined by fitting Richards' curves to age specific proportions of mature females in scientific samples taken by Russian scientists in the Greenland Sea pack ice in May-June in the years 1990-94. Samples from the Denmark Strait (1956-60) and South Greenland (1970-71) previously analysed by the back calculation method were also included in the present analyses. Although there were annual difference in MAM among the Greenland Sea samples a common MAM of 4.8 years could be fit to all years . Similarly, a common MAM of 3.1 year could be fit to the two Northwest Atlantic samples. This represents a temporal and a stock

specific split in the sample and it cannot be concluded which factor is more important. Ovulation rates of mature females ranged from 0.68 in May 1990 to 0.99 in June 1991 and 1992, but the average ovulation rate of 0.88 was similar to previous estimates for Northwest Atlantic hooded seals. For breeding and moulting patch samples taken in the period 1986-1990, indirect measures of pregnancy rates derived from patterns of alternation in corpora formation between ovaries ranged from 0.74 to 0.97 and were significantly lower in 1987 and 1988 than in all other samples including the older data for the Northwest Atlantic stock ranging from 0.94 to 0.97.

Data on the age distribution in Russian catches of hooded seals in the Greenland Sea during 1975-1994 was provided and used in modelling abundance in the Greenland Seat (Svetochev, this meeting, SEA 150).

4.2.4 Population Assessment

Pup Production

Oien summarized the results of hooded seal pup surveys conducted by Norway in March 1997 (Oien, this meeting SEA 163) using fixed-wing aircraft and a ship borne helicopter in the Greenland Sea pack-ice. Two aircraft conducted reconnaissance flights at altitudes of about 800 feet, depending on weather and visibility conditions, from the Jan Mayen base, and the ship borne helicopter searched from the vessel K/V Lance. The search area was the pack-ice between 70°N and 75°N. The largest patch of breeding hoods was found in an area to the northeast of Jan Mayen. Due to the very good survey conditions over the period 17 March to 24 March, reconnaissance flights were conducted every day with the exception of 21 March. As such, the probability that large hooded seal concentrations were overlooked was small assuming that the time of formation of breeding lairs did not deviate considerably from the assumed time of around 18 March, and that no breeding lairs were formed within the fast ice at East Greenland (which was not covered due to fog problems). Photographs were taken in 6 of the recorded hooded seal breeding lairs, and 2 replicate surveys were made of the main whelping concentration K02. Of the patches covered, K04 apparently was an early stage of the patches K07 and K08, and thus one total estimate is given with K04 excluded. Stage determination of hooded seal pups was conducted in several of the breeding patches, starting 18 March (day 1) in patch K01, continuing 20 March (day 3) in patch K02, and from 25 March (day 8) on the northwestern side of Jan Mayen. The stages used in the classifications were: 1 - newborn, abdomen yellow, 2 - thin, abdomen white, neck distinct, 3 - fat, neck not discernible, 4 - solitary pup. It seems that the maximum proportion of newborns was reached 22 March, mainly based on data collected in patch K02, but the maximum in patch K01 must have been much earlier, as more than 70% were staged 2 on day 1, i.e. 18 March. In the western patches the occurrence of large proportions of stage 2 pups at days 8 and 12 may indicate a later birth maximum. All together, the data indicate that the birth period for hooded seals in the Greenland Sea extends over the period from about 15 March to 30 March as a minimum, and that there might be several peaks during the period. The estimate of total production in all patches was 23,762 pups (CV = 19.0, CI = 14,819 – 32,705). This estimate is not corrected for the temporal distribution of births or for pups that may have been born outside of these whelping concentrations.

Salberg next presented information on the hooded seal pup aerial surveys conducted from 11 to 29 March 2005 in the Greenland Sea pack-ice (Salberg et al., this meeting, SEA 163). Two fixed-wing twin-engine aircraft were used for reconnaissance flights and photographic strip transect surveys of the whelping patches once they had been located and identified. A helicopter assisted in the reconnaissance flights, and was used subsequently to fly visual strip transect surveys over the whelping patches. The helicopter was also used to collect data for estimating the distribution of births over time, and to assess the fidelity of solitary pups to their natal ice pans. Three hooded seal breeding patches (A, B and C) were located and

surveyed either visually (A and B) and/or photographically (all patches). Due to concerns about incomplete coverage, the visual surveys were rejected and only the photographic surveys applied to estimate the pup production. Results from the staging flights suggest that the majority of hooded seal females in the Greenland Sea whelped between 17 and 23 March. The calculated temporal distribution of births and estimated availability of solitary bluebacks for aerial observations within the whelping patches was used to correct the abundance estimates obtained. The total estimate of pup production was 15,200 (SE = 3,790), giving a coefficient of variation for the survey of 24.9%. This estimate, uncorrected for pups born outside the whelping concentrations and therefore slightly negatively biased, is considerably lower than the estimate obtained with similar methodology in the Greenland Sea in 1997.

Population Model

The model used to assess the abundance for NE Atlantic hooded seal population was presented and used at the last WGHARP meeting (ICES CM 2006/ACFM:6). The population model estimates the current total population size using historical catch data and estimates of pup production. In principle, the model can also estimate biological parameters (M1+, M0 and F), but for the Greenland Sea hooded seal stock there is insufficient data to provide accurate estimates of M1+, M0. To compensate for the lack of data, information from other similar populations is used as input to the model in the form of a prior distribution (mean and standard deviation) for M1+ and M0.

The parameters of the model are:

- $N_{0,t}$ = Number of pups born in year t,
- $N_{1+,t}$ = Number of individuals at age i in year t,
- N_{1945} =Population size in 1945,
- M_0 = Pup mortality,
- M_{1+} = Mortality among 1+ animals,
- $P_{i,t}$ proportion of females at age i being reproductively active in year,
- F = Natality rate (i.e. proportion of mature females giving birth)

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

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

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

$C_{0,t}$ = catch in numbers of pups in year t,
$C_{1+,t}$ = catch in numbers of 1+ animals in year t.

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

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

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

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

The pup production is given as:

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

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

The estimated parameters are N_{1945} (the population size in 1945) along with the biological parameters M1+, M0 and F. These are found by minimizing an objective function consisting of the weighted (according to survey standard deviation) sum of squares of the differences between the model value and the survey estimates of pup production. A penalty term resulting from the assumed (normal) priors on M1+, M0 and F is also added to the objective function. AD Model Builder is used to minimize the total objective function. AD Model Builder calculates standard deviations for the model parameter, as well as the derived parameters such as present population size.

Population estimates

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

Table 1. Estimates of proportions of mature females (p) at ages 2-11 (this meeting SEA 162).

Age	2	3	4	5	6	7	8	9	10	11
p	0.05	0.27	0.54	0.75	0.87	0.93	0.97	0.98	0.99	1.00

Table 2. Estimates of Greenland Sea hooded seal pup production (this meeting SEA 163 and SEA 148)

Year	Estimate	c.v.
1997	24,000	.28
2005	15,200	.249

Model runs were performed over a range of M1+, M0 values (0.09 to 0.13, 0.27 to 0.36) with standard deviations of either 0.01 or 0.05. Summary statistics for the model run using the fitted model and model diagnostics for the prior distribution of M1+ = 0.11 (std = 0.05) are given in Table 3, and Fig. 1. In this case the population was modelled assuming future catches at PBR level.

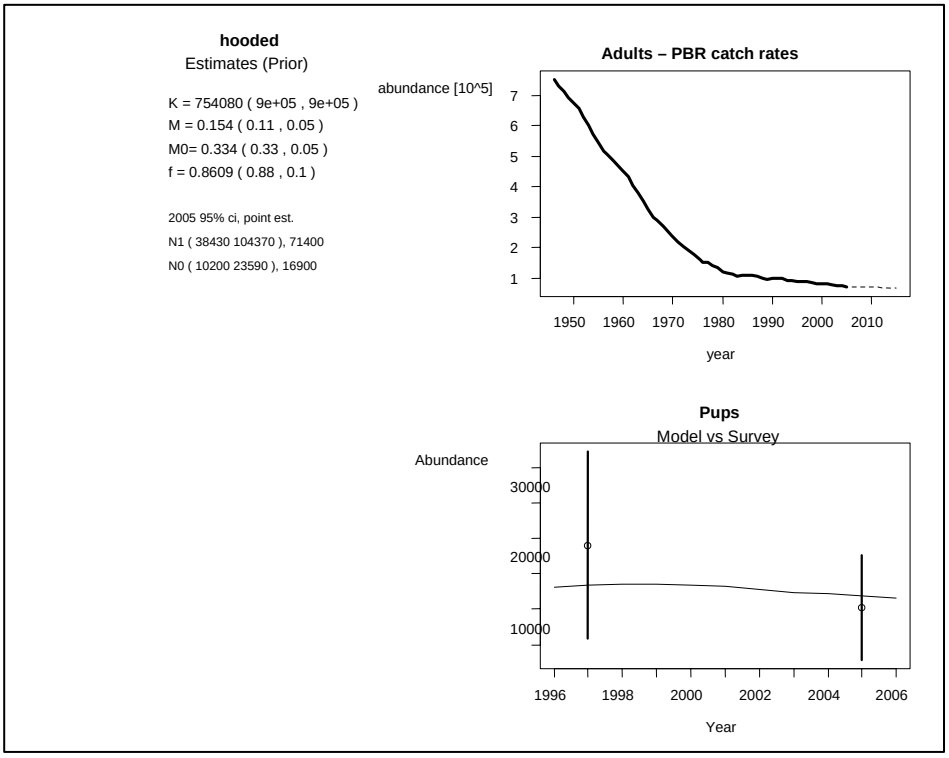

Figure 1. Greenland Sea hooded seal stock abundance estimate using prior values of M_{1+} = 0.11 (std = 0.05), M_0 = .33 (std = 0.05) , and F = .88 (std = 0.1).

All model runs (SEA 164) indicated a substantial decrease in population abundance from the late 1940s and up to the early 1980s. In the most recent two decades, the stock appears to have stabilized at a low level, but the current trajectory is uncertain. The model is very sensitive to M1+ which is poorly estimated because the model is fit to only two data points. Therefore, we assumed an a priori M1+ that was imprecisely known (std 0.05). The resulting estimate M1+ varied slightly depending upon the prior, but was always higher than the prior mean (in the 0.14-0.16 range). Regardless of the assumptions concerning M1+, all model runs gave very similar results with regard to present abundance – this is due to the 2005 pup production estimate. Using a prior value of M1+ of 0.11 (std 0.05), a 2005 abundance of 71,400 is obtained (Table 3). A 95% confidence interval for this N1+(2005) is 38,430 – 104,370. The number of pups present in 2005 is estimated to be 16,900 (std 3,418) resulting in an estimate of total population of 88,300.

Table 3. Estimated 2005 status of hooded seals in the Greenland Sea with a prior value of M_{1+} of 0.11 (std 0.05). The column "Estimate" shows the estimated parameters (point estimate and standard deviations), while the column "Prior" shows the prior distributions placed on parameters.

	Estimate		Prior	
	Est.	SD	Mean	SD
M_{1+}	0.154	0.037	0.11	0.05
M_0	0.334	0.050	0.33	0.05
F	0.8609	0.099	0.88	0.1
N_{1+}(2005)	71,400	16,823		
N_0(2005)	16,900	3,418		

4.2.5 Catch options

In June 2005 the Norwegian Royal Ministry of Fisheries and Coastal Affairs requested ICES to assess the status of the stocks of harp and hooded seals in the Greenland Sea and harp seals in the White Sea/Barents Sea. Advice was also requested as to the impact on these stocks of an annual harvest of 1) the current harvest, 2) sustainable catches (defined as the fixed annual catch that stabilizes the future 1+ population) and 3) twice the sustainable catches as defined above. The advice related to the harp seal populations in the Greenland Sea and White Sea/Barents Sea was provided during the 2005 WGHARP meeting (ICES CM 2006/ACFM:06). However, advice for Greenland Sea hooded seals was deferred to this June 2006 meeting when results from recent surveys would be available.

At its 2003 meeting (ICES CM 2004/ACFM:06), WGHARP presented an outline of an approach for incorporating the Precautionary Approach to the management of harp and hooded seals. Additional clarification of this approach was provided at the 2005 meeting of WGHARP (ICES CM 2006/ACFM:06). In this approach advice is provided depending upon the level of knowledge available for a stock. Stocks with recent, accurate estimates of abundance, reproductive rates, and harvest data (notably age structure and total harvest) are considered to be 'Data Rich', and catch advice is provided using the appropriate population model. If these data are unavailable, the species should be considered 'Data Poor'. In 'Data Poor' situations, the uncertainty associated with the impact of a particular management action increases and as a result, more caution is required. At the current meeting WGHARP reviewed the data available on Greenland Sea hooded seals. Although a survey was carried out in 2005, the Working Group concluded that this population should still be considered as 'Data Poor'.

WGHARP includes under its Precautionary Approach to the management of harp and hooded seals the catch option that all harvesting should be terminated if stock size falls below N_{lim} (defined as 30% of N_{max}). Using the best estimate available for N_{max} from the model runs conducted at this meeting, it appears that the current stock size of Greenland Sea hooded seals is well below 30% of N_{max} (this meeting, SEA 164). All of the population modelling suggests that the population has decreased substantially since the 1950s. Though the model runs suggest the population may have stabilized since the 1970s, the stock's trajectory remains uncertain. As such, WGHARP's harvest advice for this stock is that it not be harvested until its abundance exceeds N_{lim}.

WGHARP explored the potential outcome of continued harvests. One potential approach would be to attempt to identify the maximum allowable removals that will ensure that the acceptable risk of the population falling below this reference point is only 5%. This is the general approach recommended by WGHARP for setting catch levels for data poor stocks. This level has been referred to as the Potential Biological Removal (PBR; Wade and Angliss 1997) and is calculated using default values and a minimum estimate of abundance as follows:

$$PBR=0.5 \cdot R_{max} \cdot F_r \cdot N_{min},$$

where R_{max} is the maximum rate of increase for the population , F_r is a recovery factor with values between 0.1 and 1, and Nmin is the estimated population size using 20th percentile of the log-normal distribution (Wade and Angliss 1997; Wade 1998). R_{max} is set at a default of 0.12 for pinnipeds, unless there is evidence for other more appropriate rates. The PBR approach has the added advantage that the simulation trials used to establish the appropriate population size (N_{Min}) ensured that the formulation was robust when the model assumptions were relaxed and plausible uncertainties were included.

The WG also agreed that in calculating PBR, the recovery factor (F_r) should be set to 0.5 for stocks considered to be below N_{lim} or in situations where the population cannot be determined. For Data Poor stocks considered to be above N_{lim}, the recovery factor of 0.5 should be used if

the population is considered to be decreasing or have unknown status, and F = 0.75 for populations thought to be increasing.

While the PBR approach may produce a harvest that will not deplete the stock, it is not the same as the sustainable catch option from the Norwegian request, where sustainable catches are defined as the fixed annual catches that stabilizes the future 1+ population.

Using the PBR approach, the catch limit could be set at 2,189 animals. However, even this low level of harvest produces a small chance that the harvest could extirpate the stock within 10 years (this meeting SEA 164) and there is a large chance that the population will not increase in the foreseeable future. This is because of the small size of the Greenland Sea hooded seal stock and the relatively low precision in the population estimates. The existing harvest level (3,826 seals in 2005) or a harvest at twice the level of the sustainable catch (4,378 seals) would have an even greater risk of extirpating this stock.

WGHARP recommends that no harvest be allowed for Greenland Sea hooded seals at this time because the stock size is below N_{lim}. This follows the Precautionary harvest strategy developed by WGHARP in its 2003 and 2005 meetings.

4.3 Northwest Atlantic Hooded Seals

4.3.1 Recent catches and regulatory measures

A summary of information on catches of the Northwest Atlantic hooded seal stock during 1954-2006 was presented by Stenson (Stenson, this meeting, SEA 151). Seals are killed during a subsistence harvest in Greenland and a commercial hunt in southern Canadian waters. In addition to the reported catches, seals are also killed but not recovered ('struck and lost'). Prior to the imposition of quotas in 1974, Canadian catches were highly variable, ranging from a couple of hundred to more than 25,000. Between 1974 and 1982 catches averaged 12,500 (SD=2,000) but as a result of a collapse in the major markets, catches declined after 1982. With the exception of 1 year, annual catches were in the range of a few hundred until the mid 1990s. In 1996, a large number of bluebacks were taken illegally while a subsidy for meat resulted in catches of over 7,000 in 1997 and 1998. Since then, the annual harvests of hooded seals in Canadian waters have remained low. Between 1945 and 1960 moulting hooded seals were hunted by Norwegian vessels in the Denmark Strait. Annual catches ranged from 1,500 - 48,000 and averaged 14,500 (SD = 10,800). Less than 1,000 seals were taken by Norwegian scientists biennially between 1970 and 1978. Catches in Greenland were between 1,000 and 2,000 between the mid 1950s and 1972 (Av = 1,600, SD = 600). Since then catches have ranged from 3,000 - 10,000, being in the 6,000 – 7,000 range in most years. Total removals averaged 34,800 (SD = 10,200) seals between 1954 and 1960. Throughout the 1960 annual catches varied greatly. From 1974 - 1982, hooded seals catches were relatively steady averaging 24,600 (SD = 2,000). With the exception of three years (1996-98) catches have averaged 8,100(SD = 1,900) since 1982. The majority of hooded seals are caught in Greenland. With the exceptions of the 1963-1982 period when Canadian catches accounted for over 70% of the annual catches, Greenland accounted for over 65% of the hooded seals killed. The proportion of young in the harvest has remained consistent with approximately 30% being young of the year.

4.3.2 Current research

A current study on the movements of hooded seals in the northwest Atlantic is described under Section 4.1. Preliminary results of other ongoing studies are described below.

4.3.3 Biological parameters

Kapel presented data on age frequencies in samples of hooded seals collected by hunters in Greenland (Kapel, this meeting, SEA 154). Between 1970 and 1991, more than four thousand hooded seal jaws were collected in Greenland, of which about 2,000 come from South Greenland, 700 from South East Greenland, and 1,400 from North West Greenland (including some specimens from Central West Greenland). The samples were dominated by adult seals, particularly males, whereas sub-adults were rather weakly represented, and especially young-of-the-year. The validity of the samples were discussed, and some suggestions were given on how to use the data for estimating the composition of hooded seal catches in Greenland as a whole.

Stenson presented research on the reproductive rates of northwest Atlantic hooded seals females collected at the whelping concentration off Newfoundland between 1979 and 2003 (Duffet et al., this meeting, SEA 160). As most of the specimens were collected during the lactation period or immediately after and therefore, were not representative of the population, a modified version of a method used to estimate reproductive status in years prior to collection was used. The assumptions involved in this method were that corpora albicantia decrease in size as they age, that animals ovulate once per year, and that ovulation alternates between ovaries. These assumptions were tested and concluded to be valid for calculating pregnancy rate for one year prior to the year of collection. The samples were grouped into 4 block of years, 1979, 1984-85, 1990-94 and 1999-2003. Pregnancy rates were lower in 1990-1994 than in 1979 while mean age at maturity was lower in 1990-94 than in the earlier samples. The most recent samples (1999-2003) had very low sample sizes, and differences between this period and others were difficult to interpret.

Stenson next presented the results of a study of seasonal and density effects on hooded seal growth and condition (Chabot et al., this meeting, SEA 161). The main objectives of this study were to describe growth in mass for this species, to describe seasonal changes in mass and condition, and finally to compare size hooded seal growth and condition between the 1980s and the 1990s - early 2000s. Gompertz growth curves were fitted to Mt, Ms, Mc, G and L of hooded seal growth and condition for each of four seasonal periods. The fits were all significant ($P < 0.0001$) and the fitted line was at the center of the size distribution for seals at all ages. The three condition indices computed from the allometric equations were quite impervious to age differences between seals from a same period. Selecting only seals ≥ 7.5 years old further ensured that comparisons of condition across seasons or across decades were not driven by differences in age distribution between samples. General condition of female hooded seals peaked before whelping although many females were in as good a condition during whelping as those females sampled prior to whelping. General condition was influenced by changes in both sculp and core mass, which can be contradictory. A clearer pattern of reduction in condition was visible when examining seasonal variations in sculp condition and blubber thickness. These indices were clearly at their highest values during the prereproduction period, even though some high values were also observed in lactating females. Overall these lipid-sensitive indices declined sharply during reproduction. Sculp condition appeared to improve by late May, whereas blubber thickness only increased marginally, but these changes were based on small sample sizes. General condition did not change much between February and September in male hooded seals. With respect to decadal variability, all indices showed a significant interaction with the factor Years, with condition being greater during the early years of the time series than for the period 1990 to present. These changes may be due to density dependent factors related to increases in abundance or decrease in major prey species.

An analysis of the timing of whelping among Northwest Atlantic hooded seals was then presented (Hammill, this meeting, SEA 153) Stage data used in the analyses were collected at the Front and in the Gulf of St. Lawrence in 1990, 1994, 2004, and 2005. The timing of births

varied among years and between patches within a single year. At the Front, the mean date by which pupping had finished was 28 March (SE=2.21, N=8, Range =18 March-4 April). In the Gulf, pupping in most years had finished by the start of April, with the exception of 1994, when the model predicted that pupping continued until May. This late date and high standard error indicate a very poor model fit to the data. Excluding the 1994 patch ,the season of births in the Gulf ends by the 27 March (SE=1.79, N=5, Range=25 March -2 April).

4.3.4 Population Assessment

Pup Production

Stenson presented the results of the 2005 pup production surveys for hooded seals in the Northwest Atlantic (Stenson et al., this meeting, SEA 152). Photographic and visual aerial surveys to determine current pup production of Northwest Atlantic hooded seals were conducted off Newfoundland, in the Gulf of St. Lawrence in March 2004, and off Newfoundland, in the Gulf and in Davis Strait during 2005. Surveys in the Gulf and Front were corrected for the temporal distribution of births and the misidentification of pups by readers. In 2004, pup production at the Front was estimated to be 123,862 (SE = 18,640, CV = 15.0%). Pup production in the Gulf was estimated to be 1,388 (SE = 298, CV = 21.6%) although this is considered to be negatively biased. In 2005, pup production at the Front was estimated to be 107,013 (SE = 7,558, CV = 7.1%) while 6,620 (SE = 1,700, CV = 25.8%) pups were estimated to have been born in the Gulf. Pup production in the Davis Strait whelping concentration was estimated to be 3,346 (SE = 2,237, CV = 66.8%). Combining these areas resulted in an estimated pup production in the three northwest Atlantic whelping areas of 116,900 (SE = 7,918, CV = 6.8%). Comparison with previous estimates suggests that pup production may have increased since the mid 1980s. However, any understanding of changes in abundance is hampered by a lack of understanding of the relationship among whelping areas.

Population Estimate

Stenson next presented the most recent estimate of total population abundance for Northwest Atlantic hooded seals (Hammill and Stenson, this meeting, SEA-155). A population model incorporating pup production estimates since the 1980s, reproductive rates and human induced mortality (catches, by-catch in fishing gear and struck and lost) were used to estimate total abundance for the period 1960 - 2005.

The model fit to survey estimates of pup production by adjusting the initial population size and adult mortality rates to minimize the mean sum of square differences between pup production estimated by the model, and estimates obtained from survey data. Pup mortality was fixed at three times adult mortality.

Model structure

The basic model has the form :

$$n_{a,t} = ((n_{a-1,t-1} * w_t) - c_{a-1,t-1})e^{-(\gamma)m} \quad (1)$$

for a =1

$$n_{a,t} = (n_{a-1,t-1}e^{-m/2} - c_{a-1,t-1})e^{-m/2} \quad (2)$$

for 1 < a < A,

$$n_{A,t} = (n_{A-1,t-1}e^{-m/2} - c_{A-1,t-1})e^{-m/2} \quad (3)$$

for a = A, where A-1 is taken as ages A-1 and greater, and for a = 0;

$$n_{0,t} = \sum_{a=1}^{A} n_{a,t} P_{a,t} \qquad (4)$$

where $n_{a,1}$ = population numbers-at-age a in year t,

$c_{a,t}$ = the numbers caught at age a in year t,

$P_{a,}t$ = per capita pregnancy rate of age a parents in year t, assuming a 1:1 sex ratio. P is expressed as a Normally distributed variable, with mean and standard error taken from the reproductive data

m = the instantaneous rate of natural mortality.

γ = a multiplier to allow for higher mortality of first year seals. Assumed to equal 3, for consistency with previous studies.

w = is the proportion of pups surviving an unusual mortality event arising from poor ice conditions or weather prior to the start of harvesting.

A = the 'plus' age class (i.e. older ages are lumped into this age class and accounted for separately, taken as age 25 in this analysis).

The model was adapted to function within an EXCEL spreadsheet and incorporated uncertainty in the parameters using an EXCEL add in called @Risk (@Risk , Palisade Corporation 2000).

A second feature called RiskOptimizer uses generic algorithms to search for optimal answers to simulation models (Palisade Corporation 2000). For some model inputs (e.g. reproductive rates) information is available to describe sample variability in our estimates (mean and standard error). To capture some of the variability in these parameters, single parameter values were replaced by statistical distribution functions with mean and standard error estimated from the available data. In the current fitting of the model, the uncertainty in the population trajectory was estimated using the following re-sampling scheme. The set of pup production estimates were re-sampled (N=100) assuming that the survey estimates of pup production, $\tilde{n}_{0,t}$, are normally distributed as:

$$\tilde{n}_{0,t} \sim \mathrm{N}(n_{0,t}, \tilde{\sigma}^2_t),$$

where $n_{0,t}$ is the true pup production for year t, and $\tilde{\sigma}^2_t$ is the estimated variance of $\tilde{n}_{0,t}$.

where $N_{0,t\,j}$ is the j-th re-sampled estimate of $n_{0,t}$. Samples were drawn from the reproductive rates, and pup survey estimates. For each set of pup production estimates the model was refitted by calculating new estimates of initial population size and adult mortality rates, which in turn were used to generate population trajectories.

The model was fitted to the independent estimates of pup production obtained from the aerial surveys between 1984 and 2005 (Stenson et al., this meeting, SEA 152), removals from the population obtained from Stenson (this meeting, SEA 151) and reproductive rates from Duffet et al (this meeting SEA 160). In addition, variable environmental conditions were considered to have had an impact on mortality rates among years. Specifically, poor ice conditions and extensive storm activity has probably resulted in higher than normal mortality rates for pups. Higher mortality was included in the model, as wt (equation 1) and set at 0.25 in 1981 and 2005.

Hooded seal pup production and total population size are affected by the type of pup production estimates that the model is fitted to. Using only pup production estimates from the Front, pup production in 2005 was 108,200 (SE=24,500; 95% C.I.=87,300-153,900) for a total population of 537,100 (SE=122,500; 95% C.I. 294,600-779,600). Fitting to pup production estimates from all herds and making assumptions about numbers of hooded seals in the Davis Strait herd for years when this area was not included in the survey program, results in pup production estimates of 119,800 (SE=19,200; 95% CI=81800-157,800) and an estimated total population of 592,100 (SE=94,800; 95% C.I.= 404,400-779,800). There is considerable uncertainty associated with these estimates which results from: 1) a lack of understanding of the relationship between the Davis Strait, Front, and Gulf pupping areas, 2) the limited number of surveys of all three areas, 3) the limited reproductive data, and 4) uncertain harvest statistics.

Under the criteria outlined by WGHARP and the Canadian Objective Based Management (OBFM) Approach Northwest Atlantic hooded seals are considered to be 'Data Poor' and therefore, the Potential Biological Removal (PBR) algorithm (Wade and Angliss 1997) should be used to provide catch options. The OBFM approach does not currently specify the level of F_r to be used but based upon N_{min} values for 'Front Only' and 'All Areas' populations of 436,900 and 511,600, respectively and F_r = 1.0, results in estimates of PBR of 26,200 and 30,700 animals, respectively (Hammill and Stenson, this meeting, SEA-155). However, the general control rule adopted by WGHARP for "Data Poor" stocks during this meeting (see above) recommends that a F_r value of 0.75 is more appropriate for this population. Using this value the PBR reference levels are estimated as 19,650 and 23,025 animals for the Front Only and All Areas, respectively.

5 Advice for ACFM and NAFO

The chairman of WGHARP, with assistance from Haug and Stenson, will prepare the draft advice for ICES and NAFO based on the results of this meeting, and circulate the advice to the WG for their review.

6 Other business

The WG was informed of a request to ICES and NAFO from the North Atlantic Marine Mammal Commission (NAMMCO) for advice on North Atlantic harp seals. The WG was informed that NAMMCO presently has no Memorandum of Understanding with either ICES or NAFO and therefore until a MOU is approved such requests should be submitted through their member nations (e.g., Greenland).

The WG discussed an appropriate outlet for the workshop manuscripts. The participants agreed that it would be useful to compile the papers in a single location. For those papers that will be published elsewhere, an extended abstract could be included. Three possibilities were considered: the ICES Journal of Marine Science, the NAFO Journal of Northwest Atlantic Fisheries Science, and the U.S. National Oceanographic and Atmospheric Administration's (NOAA's) Technical Report series. The latter appears to be the quickest and simplest outlet for publication and the Chair was requested to discuss this further with NOAA publication's staff.

7 Adoption of the report

The WG adopted the report by correspondence effective 30 June 2006.

Annex 1: List of participants

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Annex 2: Agenda

Monday

10:00am to 10:30am -- Introductory Comments (Merrick, Haug and Stenson)

10:30am to 11:00am -- Brief retrospective on Hooded Seal Research (Kapel)

11:00am to noon -- Stock Identity, Distribution and Migration

Overview on Stock Structure

- Coltman, D. W. et al. Panmictic population structure in the hooded seal (*Cystophora cristata*) (*WP SEA 158*)

Greenland Sea Stock

- Read: Folkow, L. 1996. Annual distribution of hooded seals (Cystophora *cristata)* in the Greenland and Norwegian Seas (*No WP SEA number*)

Noon to 1:00pm -- Lunch

1:00pm to 2:30pm -- Stock Identity, Distribution and Migration

Greenland Sea Stock (cont)

- Svetochev, V. N. and V. A. Bondarev. Distribution of hooded seals in the Greenland Sea during 1955-1994 (*WP SEA 149*)

Northwest Atlantic Stock

- Stenson, G. et al. Tagging of Northwest Atlantic hooded seals (1983-2006): Implications of stock structure (*WP SEA 157*)
- Stenson, G. et al. The seasonal distribution of hooded seals, *Cystophora cristata*, in the Northwest Atlantic (*WP SEA 159*)

2:30pm to 3:00pm -- Recent Catches and Regulatory Measures

Greenland Sea Stock

- Haug, T. Catches of and regulatory measures for hooded seals in the Greenland Sea (*WP SEA 156*)

Northwest Atlantic Stock

- Stenson, G. Hunt induced mortality in Northwest Atlantic hooded seals. (*WP SEA 151*)

3:00pm to 3:30pm -- Break

3:30pm to 5:30pm -- Ecological Relationships

Greenland Sea Stock

- Haug, T., Nilssen, K.T., Lindblom, L. and Lindstrøm, U. Diets of hooded seals (Cystophora cristata) in coastal and drift ice waters along the east coast of Greenland. *(WP SEA 147)*
- Wilkinson, J. Relationships between ice condition and whelping patches (*No report*)

Northwest Atlantic Stock (no report)

5:30pm Break for Day

Tuesday

9:00am to 10:00am -- Biological Parameters

Greenland Sea Stock

- Read: Bergflødt, B and Øritsland, T. Frequencies of supernumery teeth in hooded seals (*Cystophora cristata*) (*No WP SEA number*)
- Svetochev, V. and Frie, A.K. Age at maturity and fertility rates in Greenland Sea hooded seals Cystophora cristata.(*WP SEA 162*)
- Svetochev, V. N.: Age Distribution In Russian Catches Of Hooded Seals In The Greenland Sea During 1975 – 1994. (*WP SEA 150*)

10:00am to 10:30am -- Break

10:30am to noon -- Biological Parameters (cont)

- Tranum-Jensen, J.: "Blubber, bones and buoyancy" (*WP SEA*)
- Read: Tryland, M. et al: Prevalence of Brucella pinnipediae in healthy hooded seals (*Cystophora cristata*) from the North Atlantic Ocean and ringed seals (*Phoca hispida*) from Svalbard (*no WP SEA number)*

Noon to 1:00pm – Lunch

1:00pm to 2:30pm -- Biological Parameters (cont)

Northwest Atlantic Stock

- Kapel, F: Age frequencies of hooded seal (*Cystophora cristata*) sampled between 1970 and 1991. (*WP SEA 154*)
- Duffet, K. A. et al. Trends in pregnancy rates and mean age at maturity in Northwest Atlantic hooded seals (*Cystophora cristata), 1979-2003.* (*WP SEA 160*)
- Chabot, D. et al. Growth and condition of hooded seals (*Cystophora cristata*): seasonal and density effects. (*WP SEA 161*)
- Hammill, M. and G.B. Stenson. Timing of whelping among Northwest Atlantic hooded seals, *Cystophora cristata*. (*WP SEA 153*)

2:30pm to 3:30pm -- Population Assessments

Greenland Sea Stock

- Øien, N. Aerial surveys of hooded seal pups in the Greenland Sea in 1997 (*WP SEA 163*)
- Salberg, A.-B., Haug, T. and Nilssen, K.T. Estimation of hooded seal pup production in the Greenland sea pack ice during the 2005 whelping season. *(WP SEA 148)*
- Salberg, A-B, and Haug, T. Abundance of hooded seals (*Cystophora cristata*) in the Northeast Atlantic (*WP SEA 164*)

3:30pm to 4:00pm – Break

4:00pm to 5:30pm -- Population Assessments

Northwest Atlantic Stock

- Stenson, G., Hammill, M., Gosselin, S. and Lawson, J.: Pup production of hooded seals(*Cystophora cristata*)in the NW Atlantic (*WP SEA 152*)
- Hammill, M. and Stenson, G.: Abundance of Northwest Atlantic Hooded Seals, *Cystophora cristata* (1960 – 2005) (*WP SEA 155*)

5:30pm -- Break for day

Wednesday

9:00am to noon

- Discussions of the preceding two day's reports
- Discussion of needed research and/or potential improvements to existing research

Noon to 1:00pm – Lunch

1:00pm to 5:00pm…

- WGHarp members work Workshop report

Thursday-Friday

9am to 5 pm – WGHarp meets to prepare revised hooded seal assessment

Annex 3: WGHARP terms of reference for the next meeting

The **Working Group on Harp and Hooded Seals (WGHARP)** (Chair: R. Merrick, USA) will meet in Tromsø, Norway during August 2008 (or a date to be determined) to:

a) Update assessments for harp and hooded seals based on new data collected in winter 2007-2008 surveys;

b) Consider other requests from member states for scientific advice;

c) Address a possible request from NAFO to review the available data on seal-fishery interactions

WGHARP will report by September 2008 to the attention of the ACFM Committee, as well as the Resource Management and the Living Resources Committees.

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 ACFM 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 4.4 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:	ACFM is the parent advisory committee for WGHARP. ACE, NAFO Sc.C.
LINKAGES TO OTHER COMMITTEES OR GROUPS:	LRC, RMC, WGMME, WGNPBW There is also a working relationship with the ICES Working Group on Marine Mammal Ecology.
LINKAGES TO OTHER ORGANIZATIONS:	NAFO, 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
SECRETARIAT MARGINAL COST SHARE:	ICES 100%

Annex 4: Recommendations

RECOMMENDATION	ACTION
1. Conduct hooded seals surveys of West Ice whelping areas as soons as possible. When next Northwest surveys occurs, all three whelping areas should be covered, including complete coverage of Davis Strait. If possible, surveys of the NW and NE should be conducted together.	Norway and Canada
2. Update data on hooded seal female reproductive rates for NW Atlantic and East Greenland "West Ice"	Norway and Canada
3. Continue disease work on harps and hooded thorughout their range	Norway
4. Continue work on the relationship between hooded seal growth and condition, and environmental conditions	Canada, Norway, Russia
5. Support additional research on sea ice-hooded seal whelping relationships	Norway, Canada, United Kingdom
6. Complete hooded seal stock structure-genetic analyses	Canada
7. Deploy additional satellite tags on hooded seals to further clarify seasonal and age-related movements between NE and NW stocks	Canada and Norway
8. Clarify Greenland Sea hooded seal age structure	Norway

Annex 5: References

Working documents presented at the meeting

SEA No	Title
147	Haug, T., Nilssen, K.T., Lindblom, L. and Lindstrøm, U. 2006. Diets of hooded seals (Cystophora cristata) in coastal and drift ice waters along the east coast of Greenland.
148	Salberg, A.-B., Haug, T. and Nilssen, K.T. 2006. Estimation of hooded seal pup production in the Greenland sea pack ice during the 2005 whelping season.
149	Svetochev, V. N. and V. A. Bondarev. 2006. Distribution of hooded seals in the Greenland Sea during 1955-1994
150	Svetochev, V. N. 2006. Age Distribution In Russian Catches Of Hooded Seals In The Greenland Sea During 1975 – 1994.
151	Stenson, G. 2006. Hunt induced mortality in Northwest Atlantic hooded seals.
152	Stenson, G., Hammill, M., Gosselin, S. and Lawson, J. 2006. Pup production of hooded seals(*Cystophora cristata*)in the NW Atlantic
153	Hammill, M. and G.B. Stenson. 2006 Timing of whelping among Northwest Atlantic hooded seals, *Cystophora cristata*.
154	Kapel, F. 2006 Age frequencies of hooded seal (*Cystophora cristata*) sampled between 1970 and 1991.
155	Hammill, M. and Stenson, G.: 2006 Abundance of Northwest Atlantic Hooded Seals, *Cystophora cristata* (1960 – 2005)
156	Haug, T. 2006 Catches of and regulatory measures for hooded seals in the Greenland Sea
157	Stenson, G. Sjare, B., and Potelov, V. 2006 Tagging of Northwest Atlantic hooded seals (1983-2006): Implications of stock structure
158	Coltman, D. W. Stenson, G., Hammill, M. O., Haug, T., Davis, C. S., and Fulton, T. L. 2006. Panmictic population structure in the hooded seal (*Cystophora cristata*)
159	Stenson, G. Hammill, M. O., Poyot, F., and Fedak, M. 2006 The seasonal distribution of hooded seals, *Cystophora cristata*, in the Northwest Atlantic
160	Duffet, K. A. Stenson, G. B., and Miller. E. 2006 Trends in pregnancy rates and mean age at maturity in Northwest Atlantic hooded seals (*Cystophora cristata),* 1979-2003.
161	Chabot, D. Leblanc, M., Stenson, G. B., Kapel, F. O., and Audet, C. 2006 Growth and condition of hooded seals (*Cystophora cristata*): seasonal and density effects.
162	Svetochev, V. and Frie, A.K. 2006 Age at maturity and fertility rates in Greenland Sea hooded seals Cystophora cristata
163	Øien, N. 2006 Aerial surveys of hooded seal pups in the Greenland Sea in 1997
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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"), 1946–2005[a], incl. catches for scientific purposes.

	NORWEGIAN CATCHES			RUSSIAN CATCHES			TOTAL CATCHES		
Year	Pups	1 year and older	Total	Pups	1 year and older	total	Pups	1 year and older	Total
1946–50	31152	10257	41409	-	-	-	31152	10257	41409
1951–55	37207	17222	54429	-	-	-[b]	37207	17222	54429
1956–60	26738	9601	36339	825	1063	1888[b]	27563	10664	38227
1961–65	27793	14074	41867	2143	2794	4937	29936	16868	46804
1966–70	21495	9769	31264	160	62	222	21655	9831	31486
1971	19572	10678	30250	-	-	-	19572	10678	30250
1972	16052	4164	20216	-	-	-	16052	4164	20216
1973	22455	3994	26449	-	-	-	22455	3994	26449
1974	16595	9800	26395	-	-	-	16595	9800	26395
1975	18273	7683	25956	632	607	1239	18905	8290	27195
1976	4632	2271	6903	199	194	393	4831	2465	7296
1977	11626	3744	15370	2572	891	3463	14198	4635	18833
1978	13899	2144	16043	2457	536	2993	16356	2680	19036
1979	16147	4115	20262	2064	1219	3283	18211	5334	23545
1980	8375	1393	9768	1066	399	1465	9441	1792	11233
1981	10569	1169	11738	167	169	336	10736	1338	12074
1982	11069	2382	13451	1524	862	2386	12593	3244	15837
1983	0	86	86	419	107	526	419	193	612
1984	99	483	582	-	-	-	99	483	582
1985	254	84	338	1632	149	1781	1886	233	2119
1986	2738	161	2899	1072	799	1871	3810	960	4770
1987	6221	1573	7794	2890	953	3843	9111	2526	11637
1988	4873	1276	6149[c]	2162	876	3038	7035	2152	9187
1989	34	147	181	-	-	-	34	147	181
1990	26	397	423	0	813	813	26	1210	1236
1991	0	352	352	458	1732	2190	458	2084	2542
1992	0	755	755	500	7538	8038	500	8293	8793
1993	0	384	384	-	-	-	0	384	384
1994	0	492	492	23	4229	4252	23	4721	4744
1995	368	565	933	-	-	-	368	565	933
1996	575	236	811	-	-	-	575	236	811
1997	2765	169	2934	-	-	-	2765	169	2934
1998	5597	754	6351	-	-	-	5597	754	6351
1999	3525	921	4446	-	-	-	3525	921	4446
2000	1346	590	1936	-	-	-	1346	590	1936
2001	3129	691	3820	-	-	-	3129	691	3820
2002	6456	735	7191	-	-	-	6456	735	7191
2003	5206	89	5295	-	-	-	5206	89	5295
2004	4217	664	4881	-	-	-	4217	664	4881
2005	3633	193	3826	-	-	-	3633	193	3826

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

[b] For 1955, 1956 and 1957 Soviet catches of harp and hooded seals reported at 3,900, 11,600 and 12,900, respectively (Sov. Rep. 1975). These catches are not included.

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

Table 2. Summary of reported hooded seal catches in Canada 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	Pups	1+	Unk	Total	Pups	1+	Unk	Total	Pups	1+	Unk	Total
1946-50	4029	2221	0	6249	429	184	0	613	4458	2405	0	6863
1951-55	3948	1373	0	5321	494	157	0	651	4442	1530	0	5972
1956-60	3641	2634	0	6275	106	70	0	176	3747	2704	0	6451
1961-65	2567	1756	0	4323	521	199	0	720	3088	1955	0	5043
1966-70	7483	5220	0	12703	613	211	24	848	8096	5431	24	13551
1971	7987	6875	0	14862	54	30	0	84	8041	6905	0	14946
1972	6820	5636	0	12456	108	36	0	144	6928	5672	0	12600
1973	4499	1930	0	6429	103	35	0	138	4602	1965	0	6567
1974	5984	3990	0	9974	7	18	0	25	5991	4008	0	9999
1975	7459	7805	0	15264	187	160	0	347	7646	7965	0	15611
1976	6065	5718	0	11783	475	127	0	602	6540	5845	0	12385
1977	7967	2922	0	10889	1003	201	0	1204	8970	3123	0	12093
1978	7730	2029	0	9759	236	509	0	745	7966	2538	0	10504
1979	11817	2876	0	14693	131	301	0	432	11948	3177	0	15125
1980	9712	1547	0	11259	1441	416	0	1857	11153	1963	0	13116
1981	7372	1897	0	9269	3289	1118	0	4407	10661	3015	0	13676
1982	4899	1987	0	6886	2858	649	0	3507	7757	2636	0	10393
1983	0	0	0	0	0	128	0	128	0	128	0	128
1984	206	187	0	393[d]	0	56	0	56	206	243	0	449
1985	215	220	0	435[d]	5	344	0	349	220	564	0	784
1986	0	0	0	0	21	12	0	33	21	12	0	33
1987	124	4	250	378	1197	280	0	1477	1321	284	250	1855
1988	0	0	0	0	828	80	0	908	828	80	0	908
1989	0	0	0	0	102	260	5	367	102	260	5	367
1990	41	53	0	94[d]	0	0	636[e]	636	41	53	636	730
1991	0	14	0	14[d]	0	0	6411[e]	6411	0	14	6411	6425
1992	35	60	0	95[d]	0	0	119[e]	119	35	60	119	214
1993	0	19	0	19[d]	0	0	19[e]	19	0	19	19	38
1994	19	53	0	72[d]	0	0	149[e]	149	19	53	149	221
1995	0	0	0	0	0	0	857[e]	857	0	857[e]	0	857
1996	0	0	0	0	0	0	25754[e]	25754	22,847[g]	2,907	0	25754
1997	0	0	0	0	0	7058	0	7058	0	7058[e]	0	7058
1998	0	0	0	0	0	10148	0	10148	0	10148[e]	0	10148
1999[e]	0	0	0	0	0	201	0	201	0	201[e]		201
2000[e]	2	2	0	4[d]	0	10	0	10	2	12[e]	0	14
2001[e]	0	0	0	0	0	140	0	140	0	140[e]	0	140
2002[e]	0	0	0	0	0	150	0	150	0	150[e]	0	150
2003[e]	0	0	0	0	0	151	0	151	0	151[e]	0	151
2004[e]	0	0	0	0	0	389	0	389	0	389[e]	0	389
2005[e]	0	0	0	0	0	20	0	20	0	20[e]	0	20
2006[eg]	0	0	0	0	0	5	0	5	0	5[e]	0	0

[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 age group 0 estimated from reported illegal catches

[g] Preliminary estimates

Annex 7: Summary of hooded sea sealing regulations

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

	Opening Date	Closing Date	Quotas				Allocations	
			Total	Pups	Female	Male	Norway	Russian
1985	22 March	5 May	(20,000)[2]	(20,000)[2]	0[3]	Unlim.	8,000[4]	3,300
1986	18 March	5 May	9,300	9,300	0[3]	Unlim.	6,000	3,300
1987	18 March	5 May	20,000	20,000	0[3]	Unlim.	16,700	3,300
1988	18 March	5 May	(20,000)[2]	(20,000)[2]	0[3]	Unlim.	16,700	5,000
1989	18 March	5 May	30,000		0[3]	Incl.	23,100	6,900
1990	26 March	30 June	27,500	0	0	Incl.	19,500	8,000
1991	26 March	30 June	9,000	0	0	Incl.	1,000	8,000
1992-94	26 March	30 June	9,000	0	0	Incl.	1,700	7,300
1995	26 March	10 July	9,000	0	0	Incl.	1,700[5]	7,300
1996	22 March	10 July	9,000[6]				1,700	7,300
1997	26 March	10 July	9,000[7]				6,200	2,800[8]
1998	22 March	10 July	5,000[9]				2,200	2,800[8]
1999-00	22 March	10 July	11,200[9]				8,400	2,800[8]
2001-03	22 March	10 July	10,300[9]				10,300	
2004-05	22 March	10 July	5,600[9]				5,600	
2006	22 March	10 July	4,000				4,000	

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

[2] Basis for allocation of USSR quota.

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

[4] Adult males only.

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

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

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

[8] Russian allocation reverted to Norway.

[9] 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.

Table 2. Major management measures implemented for harp seals in Canadian waters, 1960–2005.

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

Table 3. Major management measures implemented for hooded seals in Canadian waters (1960–2005).

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