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Science | Sciences

Newfoundland and Labrador Region
Quebec Region

Canadian Science Advisory Secretariat
Science Advisory Report 2008/058

SCIENCE ADVICE ON HARVESTING OF NORTHWEST ATLANTIC HARP SEALS (*Pagophilus groenlandicus*) IN 2009

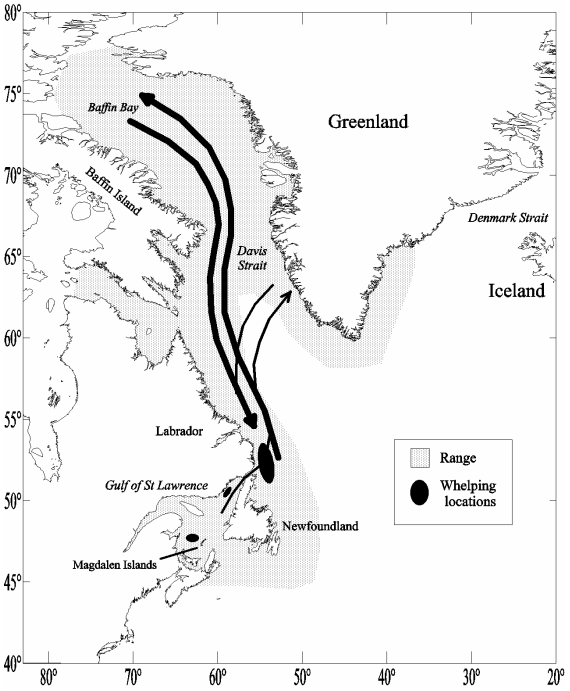

Figure 1: Range, migratory pathways and whelping locations of harp seals in the northwest Atlantic.

Context :

The Harp seal is an abundant, medium-sized seal which migrates annually between Arctic and sub-Arctic regions of the north Atlantic. Three populations of harp seals occur: the White Sea/Barents Sea, the Greenland Sea and the Northwest Atlantic. The northwest Atlantic population summers in the eastern Canadian Arctic and Greenland. In the fall, most of these seals migrate southward to Atlantic Canadian waters where they give birth on the pack ice in the Gulf of St. Lawrence ("Gulf") or off northern Newfoundland ("Front") during late February or March. Following moulting in April and May, seals disperse and eventually migrate northward. Small numbers of harp seals may remain in southern waters throughout the summer while others remain in the Arctic throughout the year.

Northwest Atlantic Harp seals are hunted throughout their range. They are harvested for subsistence purposes by Inuit in Labrador, Arctic Canada and Greenland and a commercial harvest occurs in the Gulf and at the Front. Approximately 90,000 animals are taken during subsistence harvests, mainly in Greenland. Those catches consist primarily of animals aged 1+. The commercial harvest generally removed over 300,000 seals per year between 2002 and 2006 but has declined to less than 225,000 seals per year in 2007 and 2008 due to difficult ice conditions and lower quotas .Over ninety-five percent of the commercial harvest consists of young of the year. A little over 10,000 seals are estimated to be removed incidentally during commercial fishing activities.

Subsistence harvests are currently not regulated while the commercial harvest is regulated by a five year management plan that will end in 2010.

It is not possible to survey the entire harp seal population, but the number of pups born in a year can be estimated. This information is incorporated in a population model that also integrate information on age specific reproductive rates and total removals from the population, including animals that have been killed but not recovered. Pup production is estimated periodically (4-5 year intervals) via aerial surveys conducted in the spring, when the seals gathered on the ice to have their pups. The most recent survey of pup production occurred in 2008 but the results are not available. Therefore, this estimate of total abundance of this population is based upon recent data on catches and surveys up to 2004. An estimate incorporating the 2008 survey should be available in 2009.

SUMMARY

- Northwest Atlantic harp seals are harvested in Canadian and Greenland waters. After averaging approximately 52,000 seals per year between 1983 and-1995, reported Canadian catches increased significantly to a range of 240,000 to 366,000 between 1996 and 2006. Catches were significantly reduced in 2007 (224,745) and 2008 due to lower quotas and poor ice conditions. Greenland catches have increased steadily since the mid 1970's reaching a peak of approximately 100,000 in 2000. They subsequently declined to approximately 70,000 but have since increased to 90,000 in the most recent years for which we have data (2005-06). Catches in the Canadian Arctic remain low (<1,000).

- Total removals of harp seals was estimated by including reported catches, estimates of bycatch in the Newfoundland lumpfish fishery and estimates of seals killed, but not recovered during harvesting in the different regions. From 1996 to 2004, high catches in Canada and Greenland resulted in average annual removals of 465,500. However total removals in 2008 was estimated to have declined to slightly over 400,000, primarily due to the lower catches in Canada.

- Using aerial surveys, the total pup production of harp seals in 2004 was estimated to be approximately 991,400 pups (95% confidence interval 877,300 to 1,105,500). This estimate is similar to the previous estimate obtained in 1999. A survey was carried out in 2008 but the results will not be available until 2009.

- The harp seal population declined during the 1960's and reached a minimum of less than 2 million in the early 1970's. Since then it increased steadily until the mid 1990's when it reached the highest level estimated. Due to the large harvests over the past decade, the population has been relatively stable since 1996.

- The estimated population size of northwest Atlantic harp seals for 2009 is 5.6 million (95% CI=3.9-7.2 million) animals. The most recent estimates for maximum population in 2005 is 5.7 million (95% CI= 4.4-6.9 million) which is slightly lower than the previous estimate of 5.8 million (95% CI= 4.1-7.6 million). This difference is small compared to the uncertainty in these estimates.

- Demographic momentum associated with the high harvests recorded over the last 12 years is having a major impact on the current population and pup production.

- A harvest of 270,000 animals would respect the plan in 2009, but may require substantial reductions in the TAC for the 2010 season. Harvest scenarios with catches of 300,000 animals would not respect the management objectives and would result in the projected population dropping below N70 in 2009.

- This assessment relies on pup surveys completed once every five years combined with estimates of reproductive rates and removals to determine total abundance using a population model. The variability associated with model parameters, as well as potential changes in natural mortality rates due to environmental conditions add uncertainty to these estimates. Additional uncertainty is associated with the use of pup surveys to assess abundance. Because surveys are only completed once every five years and only count pups, changes in natural mortality rates in intervening years may not be detected until 10-15 years later during subsequent assessments.

INTRODUCTION

The current five year management plan that regulates harvesting of harp seals in Canada expires prior to the 2011 hunting season. Fisheries and Aquaculture Management has requested advice on catch options for the 2009 harvest season to determine the impacts of these options on the population with respect to the management objective of maintaining an 80% probability (referred to as L_{20}) that the population is greater than the N_{70} level of 4.1 million animals. Aerial surveys of harp seal pup production were carried out in 2004 and an assessment was completed in 2005. A new survey was completed in 2008, but the results will not be available until the spring of 2009. The advice presented here is based upon the population model presented in the 2005 assessment and incorporates pup production estimates up to 2004, updated catch data for the Canadian commercial (2008) and Greenland (2006) hunts and assumed values on ice-related mortality. It has been assumed that reproductive rates and levels of bycatch have not changed since the previous assessment, and that recent catches in Greenland have averaged 85,000 animals per year. The impacts of different harvest scenarios on the population were examined.

Northwest Atlantic harp seals are managed under the Objective Based Fisheries Management approach. It is considered to be a data rich population and is managed to maintain a 80% probability that the population remains above a precautionary reference level of 4.1 million which is 70% of the maximum population size.

Species Biology

Historically the largest, the Northwest Atlantic population of harp seals summers in the Canadian Arctic and Greenland. In the fall most of these seals migrate southward to the Gulf of St. Lawrence ("Gulf"), or to the area off southern Labrador and northern Newfoundland ("Front") where they give birth in late February or March. Male harp seals are only slightly larger than females with adults averaging 1.6 m in length and 130 kg in weight. Females nurse a single pup for about twelve days, after which they mate and then disperse. The pup, known as a whitecoat, moults its white fur at approximately three weeks of age. Older harp seals form large moulting concentrations on the sea ice off northeastern Newfoundland and in the northern Gulf of St. Lawrence moult in April and May. Following the moult, seals disperse and eventually migrate northward. Small numbers of harp seals may remain in southern waters throughout the summer while a portion of the population remains in the Arctic.

The Hunt

Harp seals have been hunted commercially since the early 18th century. Canadian (primarily Newfoundland) catches increased significantly after 1820 and reached a peak of over 740,000 seals in 1832. This harvest was directed towards the oil market and was likely a mixture of pups and sexually mature females. Catches ranged from 200,000 to 600,000 throughout the remainder of the 1800s, averaging 360,000 from 1818 to 1913. During the First World War catches declined to less than 100,000 and averaged about 150,000 from 1919 to 1939. Commercial harvesting almost stopped completely during World War Two, but then increased rapidly reaching 450,000 in 1951 and averaging about 288,000 seals per year from 1952 to 1971 (Fig. 2).

The first TAC was set in 1971 at 245,000. It varied until 1982 when it was set at 186,000 where it remained until 1996. From 1972 to 1982, the average annual catch was approximately 165,000 seals. Prior to 1983, the large-vessel take of white-coated pups on the whelping patch accounted for the majority of the harvest. A ban on the importation of whitecoat pelts implemented by the European Economic Community in 1983 severely reduced the market, ending the traditional large-vessel hunt. From 1983 to 1995 catches remained low, averaging 52,000 per year. The quota was increased to 250,000 in 1996 and 275,000 in 1997 and remained stable until 2003. With the exception of 2000 when landed catches were only 92,000 animals, an average of 262,000 seals were taken annually between 1996 and 2002 (Table 1). In 2003, a 3 year management plan was announced during which a total of 975,000 seals (average 325,000 per year) could be taken with a maximum of 350,000 in any two years and the remainder in the third. A total of 985,312 animals were taken over the three years of this plan. Although the current 5-year management plan began in 2006, the multiyear quota system was not renewed. The quota was set at 335,000 in 2006 but subsequently reduced to 270,000 in 2007 due to poor ice conditions and to ensure the population was maintained above the Precautionary Reference Level. The 2008 TAC was set at 275,000. Although the quota was exceeded in 2006 (354,867), catches in 2007 (224,745) were on 83% of the TAC while catches in 2008 were 217,636 (79% of TAC). Young of the year (YOY) seals that have moulted their whitecoat ('beaters') make up over 95% of the harvest since 2000.

Harp seals are currently hunted by land-based sealers in both the Gulf and Front areas during the winter. Current regulations do not allow the hunting of adults in the whelping patch, the harvest of whitecoats or the use of vessels greater than 20 m in length.

Table 1: TAC and commercial catches of harp seals (,000s) in Atlantic Canada 1999-2008.

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
TAC	275	275	275	275	350[1]	350[1]	319.5	335	270	275
Catch	244	92	226	312	289	366	329.8	354.9	224.7	217.6

[1] Maximum annual catch under the three year management plan, totalling 975.

Prior to 1980, catches of Northwest Atlantic harp seals in Greenland were consistently less than 20,000 animals. Since 1980, Greenland catches increased relatively steadily to a peak of over 100,000 in 2000. From 2002 through 2004, catches decline to between 66,000 and 70,000. In 2005 and 2006, the last years for which data are available, reported catches were slightly over 90,000 seals. Seals of all ages are taken in Greenland with the majority being over 1 year of age.

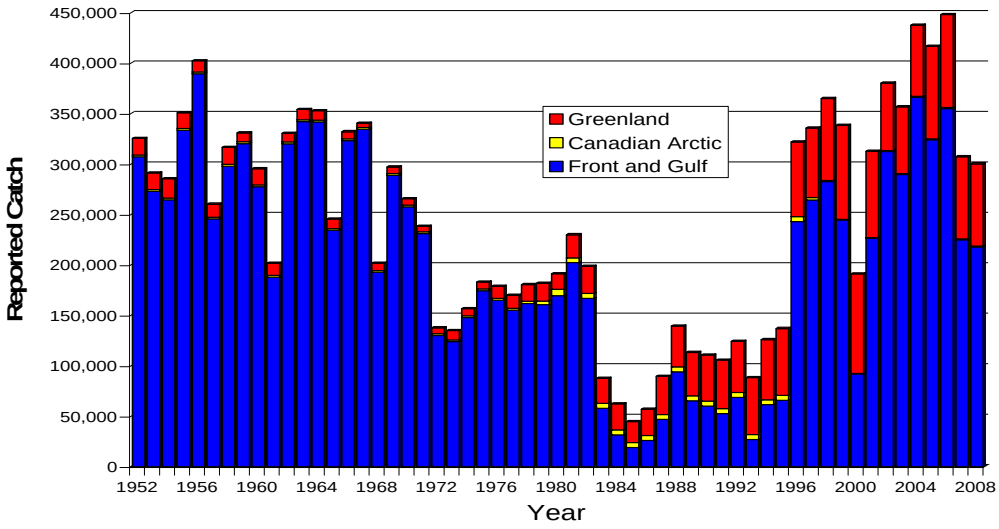

Figure 2: Reported commercial and subsistence catches of harp seals in the northwest Atlantic 1952-2008. Totals do not include seals killed but not landed or those killed as bycatch in commercial fisheries.

Other Sources of Human-Induced Mortality

In addition to reported catches, some seals are killed but not recovered or reported (referred to as 'struck and lost'). Loss rates of young seals during the large vessel, whitecoat hunt (prior to 1983) are considered to be low (~1%). Estimates of the additional mortality caused by struck and lost for young of the year seals which make up the majority of the current harvest in Canada appear to be 5% (or less) while losses of older seals are higher (assumed to be 50%). This higher figure is also applied to catches in the Canadian Arctic and Greenland when estimating total removals.

Harp seals are also taken incidentally as bycatch in fishing gear. Estimated numbers of seals taken as bycatch in the Newfoundland lumpfish fishery were generally below 1,000 seals prior to 1976; however, by the late 1980s and early 1990s catches had increased to over 10,000 in some years. Peak catch levels occurred from 1992-1996 with an average take of 29,431 seals annually. Although catches have been variable in recent years, less than 5,500 seals were taken in 2003. The lumpfish fishery is thought to be responsible for the largest bycatch mortality of seals. Seals are taken in other fisheries although the numbers caught have not been estimated. A small number of harp seals (<500/yr) are taken in fishing gear in the northeastern United States.

To estimate the total removals of Northwest Atlantic harp seals that are used in the population model, reported catches in Canada and Greenland are combined with estimates of bycatches and struck and lost. Between 1952 and 1971, removals averaged 388,000 seals, primarily due to commercial catches in southern Canada. Removals fell with the imposition of Canadian quotas in 1971, averaging just over 226,000 from 1972 to1982. The decline of Canadian catches between 1983 and 1995 resulted in fewer annual removals (average 176,000) although the contribution of struck and lost to the total increased due to the high level assumed for the Greenland hunt. Between 1996 and 2004, higher catches in Canada and Greenland resulted in average annual removals of 468,500. Total removals in 2008 were estimated to be approximately 389,000 (Fig. 3). Young of the year account for approximately 66% of the current removals.

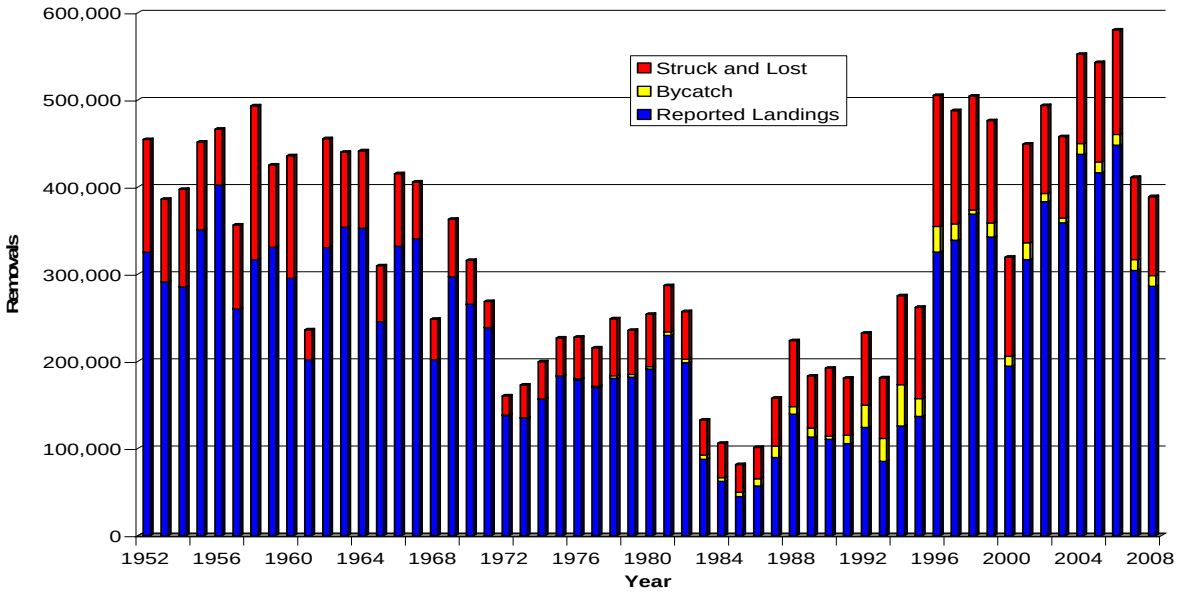

Figure 3. Total removals of Northwest Atlantic harp seals, 1952-2008.

ASSESSMENT

Resource Status

The number of harp seal pups born in a year is estimated from aerial surveys conducted in the spring, when the seals gathered to have their pups. Estimates of total population are based on a population model that incorporates independent estimates of pup production with information on reproductive rates (the age of sexual maturity and the proportion pregnant each year), catches including Canadian and Greenland harvest, bycatch and struck and lost as well as information on unusual pup mortality due to poor ice conditions.

In the past, pup production has been estimated by examining catch data, mark-recapture experiments or aerial survey techniques. The results for similar time periods were often conflicting. Estimates for the mid to late 1970's ranged from approximately 250,000 to 500,000. The Royal Commission on Seals and Sealing in Canada concluded that pup production in 1978 was in the order of 300,000-350,000 and the total population was 1.5-1.75 million. Aerial surveys, off the Front and in the Gulf of St. Lawrence, resulted in pup production estimates of 580,000 ± 78,000 pups in 1990, 703,000 ± 125,000 in 1994, 998,000 ± 200,000 in 1999 and 991,400 (± 114,100) in 2004 (all counts rounded to the nearest 1000s) (Fig. 4). Total pup production increased throughout the 1980s and 1990s (Fig. 4), but appeared to have stopped and the 2004 estimate was not significantly different from the 1999 estimate. This levelling off of pup production is due, in part, to the increased catches of young seals since 1996. This estimate was consistent with previous model predictions.

Aerial survey results indicate that the proportion born in the Gulf does vary and that the number of pups born there may be less in some years than the 1/3 assumed traditionally. For example, in contrast to 1999 when only 26% of the pupping occurred in the Gulf, a total of 35% of the pups were born in the Gulf in 2004. There is also considerable variation in the numbers of pups that are

born in the northern Gulf. These shifts may reflect changes in ice conditions, the drifting of pups into the northern Gulf through the Strait of Belle Isle, or shifts in prey abundance resulting in differences in the number of animals moving into the Gulf.

Population Dynamics

The reproductive status of female harp seals and the age structure of removals are important factors determining the dynamics of this population. To estimate the age structure, age data are obtained from the reported catch statistics and by direct sampling of seals caught by commercial sealers and researchers.

The reproductive tracts of females are examined to determine whether they are mature and if they are pregnant. Pregnancy rates have varied considerably since the 1950s. The percentage of mature females that were pregnant increased from the mid 1950s (85%) to a peak of 98% in the mid 1960s. However, it has dropped significantly from approximately 90% in the late 1970s to approximately 60-70% during the early 1990s where it has stabilized. The age at which females become sexually mature has also changed. In the mid 1950s the average age at which harp seals matured was 5.8 years whereas from the late 1970s through the mid 1980s they matured at a year younger (4.1-4.7 years of age). By the early 1990s, however, the average age of maturing had increased to approximately 5.5 years, where it has remained. The most recent data available (2002 and 2003) indicates that these lower reproductive rates are continuing. The exact timing of the recent changes cannot be determined since they occurred at a time when few reproductive samples were available. However, they appear to have taken place since the mid 1980s.

Total Population

Over the past two decades, the same basic population model has been used to estimate the total population size of harp seals in the northwest Atlantic and to run harvest scenarios for the establishment of quotas. Since it was first used, this model has been refined to improve the methods used to incorporate reproductive data and to explicitly include more sources of mortality and uncertainly in estimates of total population size. The model incorporates data on pup production since the late 1970's, reproductive rates since 1960, human induced mortality (catches, by-catch in fishing gear and struck and lost) since 1952 and ice-related mortality since 1981.

The population model indicates that pup production increased steadily from the early 1970s through to the early 2000s after which it has remained relatively constant. A slight leveling of pup production was also seen in the late 1980s, reflecting lower pregnancy rates (Figure 4).

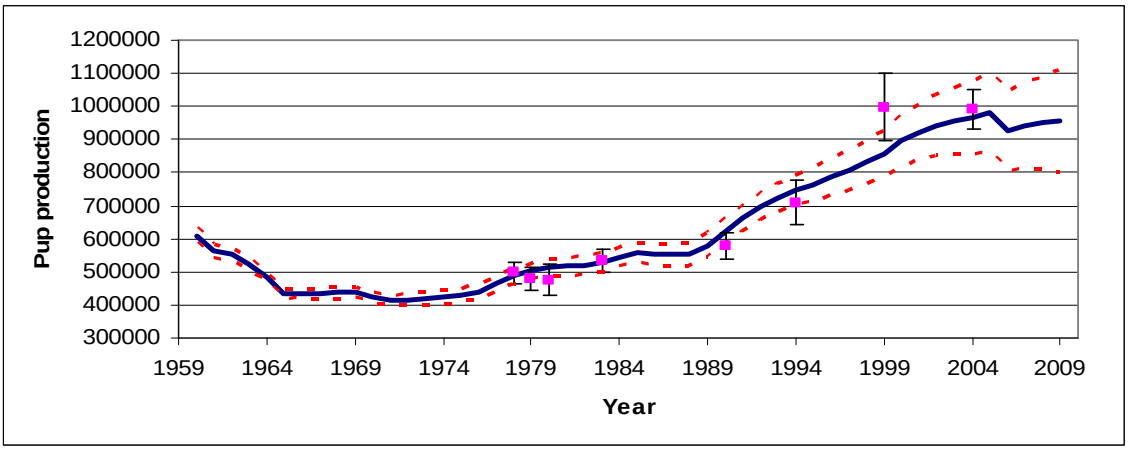

Figure 4: Independent survey estimates (±1SE) and model (±1SE) estimates of pup production 1960-2008.

Estimates of the total population declined during the 1960's, reached a minimum in the early 1970's, and then increased steadily until 1996 (Fig. 5). Since then the population appears to have remained relatively stable at the highest values in the time series. The slight differences in population since the mid 1990s are small in comparison to the uncertainty associated with the estimates and are affected by changes in the assumptions used in the model. The total population was estimated to have increased from an initial population size of 2.21 million (95% CI=2.16-2.27 million) in 1960 to 5.7 million (95% CI= 4.2-7.4 million) in 2004 and 5.8 million (95% CI= 4.1-7.6 million) in 2005. The most recent runs result in a population estimate of 5.6 million (95% CI= 4.5-6.7 million) in 2004 and a maximum of 5.7 million (95% CI= 4.4-6.9 million) in 2005. In 2009, the estimated population is 5.6 million (95% CI=3.9-7.2 million) animals (Fig. 5).

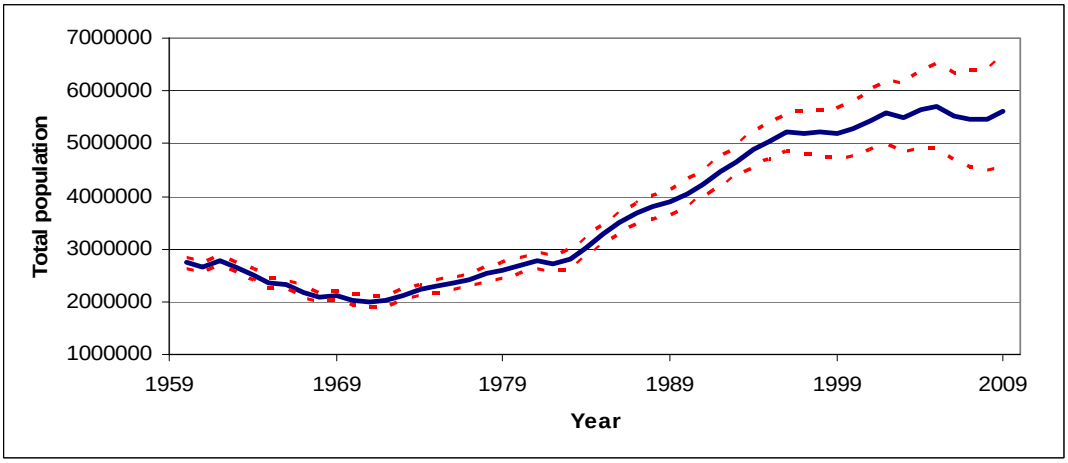

Figure 5: Estimates of total population 1960-2008 (±1SE).

The current trajectory of the northwest Atlantic harp seal population is heavily affected by population momentum associated with harvests experienced over the last 5-10 years. During the 12 year period from 1984 to 1995, the reported Canadian harvest removed on average 52,000 animals per year. Between 1996 and 2008 an average of 265,000 animals were removed annually for a total of about 3.4 million seals. The commercial harvest is directed towards Young of the Year (YOY) and therefore, the impacts of the harvest in any particular year will not be detected in the population for at least 5 years, when the harvested cohorts

reach maturity and begin contributing to the breeding population of animals. As a result there is considerable inertia in the trajectory as past TAC decisions and catches work themselves through the population. This can be illustrated in a simulation using a control population subject to an annual harvest of 200,000 animals beginning in 2009 and continuing into the future. If we apply a harvest of 500,000 animals to a single year (2009), and then return to an annual harvest of 200,000 animals, or we stop all Canadian harvests, we see that there is absolutely no difference in the pup production trajectories during a period of 5 years. After 5 years, the simulated pup productions diverge markedly as the cohort that was subjected to a very high harvest matures and enters into the breeding component (Fig. 6).

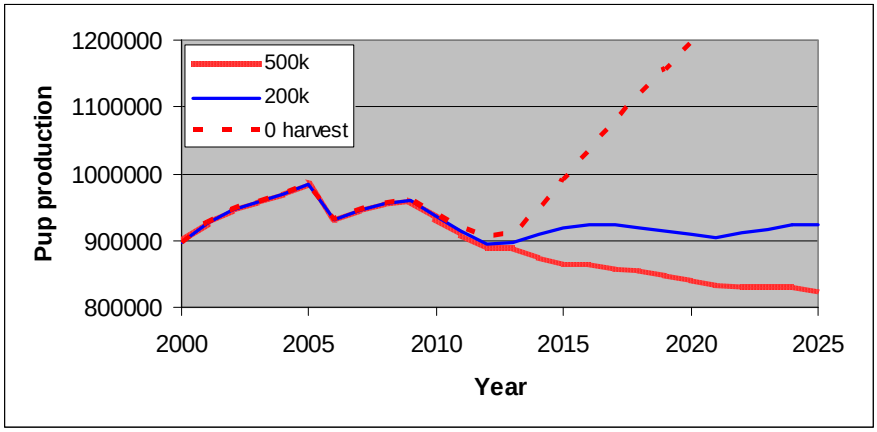

Figure 6. Changes in pup production trajectories when there is no Canadian commercial harvest, an annual harvest of 200,000, and if a harvest of 500,000 animals is applied in a single year, followed by annual harvests of 200,000 animals.

Harvest options

Fisheries and Aquaculture Management requested that four harvest scenarios (A-D) be examined within the context of a five-year management plan that ends in 2010 (Table 2). Therefore, 3 years of harvest were investigated. A fifth scenario (E) that had been presented previously was also included for comparison to previous advice.

Table 2: Harvest scenarios used to explore the impact of different Canadian catch levels on northwest Atlantic harp seals.

Scenario	2009	2010	2011
A	270,000	270,000	270,000
B	300,000	250,000	170,000
C	200,000	200,000	200,000
D	300,000	300,000	300,000
E	250,000	250,000	250,000

Scenarios with a 2009 harvest of 300,000 animals (300 k) did not respect the management plan and resulted in a prediction that the population would fall below N_{70} prior to the 2010 harvest (Fig. 7). Harvests of 270,000 and 250,000 in 2009 will allow the estimated population to remain above N_{70} after the 2009 hunt, but would result in L_{20} falling below the precautionary level (N_{70}) after the 2010 hunt. A harvest of 270,000 animals in 2009 would likely require a substantial reduction to less than 175,000 animals in 2010 to respect the management plan. A harvest of

250,000 animals in 2009 would require a lesser reduction to 225,000 animals in 2010 to respect the plan. An annual harvest of 200,000 could be carried out in 2009 and 2010 and still respect the management objective.

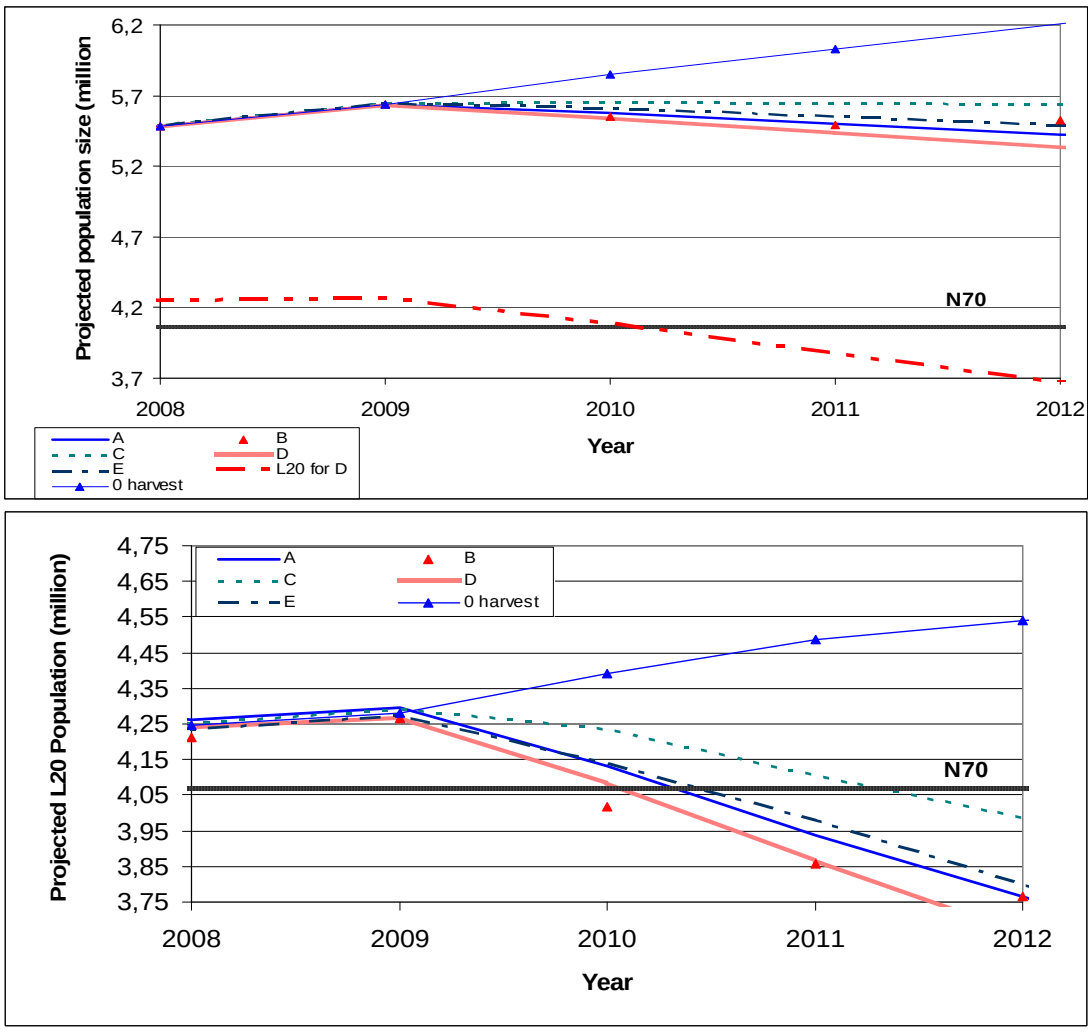

Figure 7. Estimated population trajectories under different harvest scenarios presented in Table 2. The top graph presents changes in the mean population size, with the L_{20} line for a harvest of 300,000 for 3 years present to show how L_{20} behaves compared to the mean. The bottom graph presents the L_{20} trajectories for the same harvest levels. L_{20} represents an 80% probability that the population is greater than the specified level.

Sources of Uncertainty

Removals have been estimated since 1952. However, there is uncertainty about the levels of removals over this time period. Subsistence catches (Canadian Arctic and Greenland) are uncertain, as are estimates of bycatch in Canadian fisheries. Additional catches are assumed to occur in other fisheries, but these have not been quantified. The recent Nunavut harvest study has improved our knowledge of catches in the Canadian Arctic, and indicates that we likely over-estimated harvest levels by Canadian Inuit in the past, but further improvements in reporting are required. Catches of harp seals in Greenland increased significantly until 2000 followed by a slight decline and subsequent increase in the most recent data (2006). Given the

high proportion of older animals in this harvest, Greenland catches have a greater impact on the breeding population than a similar level of Canadian catches.

The uncertainty associated with the estimates of pup production, reproductive rates and ice related mortality are accounted for in the confidence intervals. Additional uncertainty associated with total removals and the ages of catches have not been included and therefore these confidence intervals are underestimates of the total uncertainty.

The current assessment model adjusts mortality rates to fit observed data on reproductive rates and total removals to independent estimates of pup production. The model assumes that mortality does not change over the projection period. However, mortality is an important component in the dynamics of any population. Independent estimates of mortality are needed to verify model predictions and to improve information concerning the dynamics of this population.

Climate change may result in reduced availability or thickness of suitable ice in the areas traditionally used by harp seals to give birth and nurse their pups. Also, some climate models predict an increased frequency of storms during the nursing period. These climatic changes may result in increased mortality of pups or changes in whelping locations which can affect the ability of the models to provide accurate predictions of future abundance.

The primary measures of the status of the harp seal population are estimates of pup production. The scenarios examined here are based on a survey flown 4 years ago. Forward projections are expected to have higher uncertainty as time since the last survey increases. Part of this increased uncertainty is reflected in the increase in the SE and the 80% probability levels. For example the coefficient of variation around the estimate (100 *SE/mean) increases from 24% in 2004 to 32% in 2009 and this is reflected in the widening of the 80% percentiles since 2004.

In addition to the Canadian catch over the past 5-10 years, large numbers of harp seals have also been taken in Greenland (Table 2). The Greenland harvest has varied greatly over the last decade, with an average reported harvest of 81,500 (range 70,000-100,000). The Greenland harvest is not limited by quota; therefore we entered the Greenland harvest into the model as a uniform function with a range of 70,000 to 100,000 for a mean harvest of 85,000 animals. Given the age structure of the catch and the proportion of seals struck but not recovered, this level of catch has an important impact on the trajectory of the population. Also each of the projections was run assuming that the level of subsistence catch in the Canadian Arctic, bycatch in fishing gear and the age structure of the harvest remained unchanged. Current estimates of these catches are not available.

It was necessary to make a number of assumptions about future catches. Extra mortality related to poor ice conditions in 2009 and future years were assumed to follow a uniform distribution with a mean value of 12% but varied equally between 0 and 30% (0, 0.1, 0.30, 0.20, 0). Also, future Canadian catches were assumed to consist of 95% YOY. Errors in these assumptions will affect the reliability of the projections.

CONCLUSIONS

Although some modifications have occurred, the current assessment model has been used in the management of harp seals since 1980. The most recent version incorporates variability in some model parameters (e.g. reproductive rates, ice, and Greenland catches) into model projections.

Harvest scenarios with catches of 300,000 animals would not respect the management objectives and would result in the L_{20} population size dropping below N70 in 2009. A harvest of 270,000 animals would respect the plan in 2009, but may require substantial reductions in the TAC for the 2010 season. Demographic inertia associated with the high harvests recorded over the last 12 years is having a major impact on the current population and pup production. Any changes in harvests will not be detected for at least 5 years later. Actual harvests in Canada and in Greenland in 2009, and results from the survey analyses will also have an important impact on harvest scenario analyses prior to the 2010 season.

The current Canadian catch is directed almost exclusively towards young of the year seals. The high proportion of young in these catches will affect the breeding population and subsequent pup production in the coming years as these cohorts mature.

OTHER CONSIDERATIONS

Subsistence harvests in Greenland and Arctic Canada are currently not regulated. Harvest levels in these areas, particularly in Greenland, can have a significant impact on the population dynamics of this population.

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