



## STOCK ASSESSMENT OF NORTHWEST ATLANTIC HARP SEALS (*Pagophilus groenlandicus*)

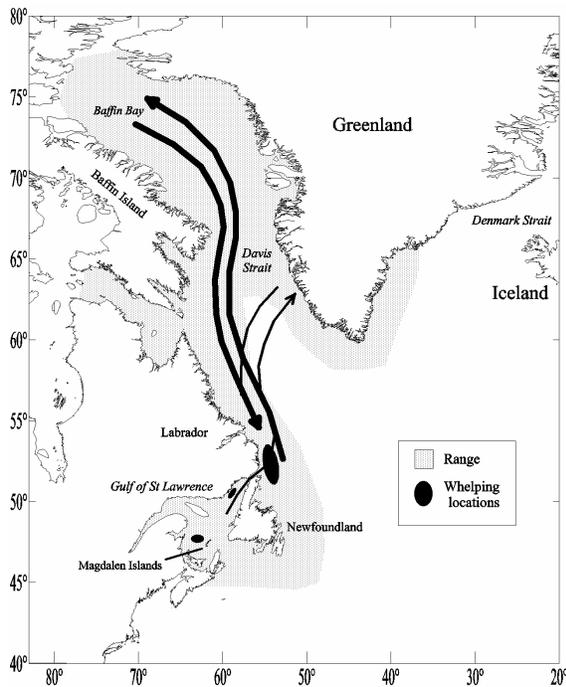
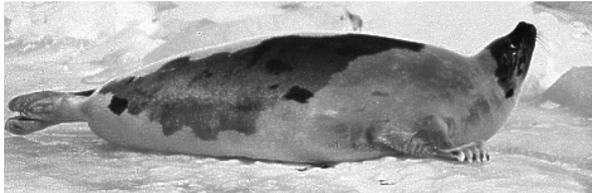


Figure 1: Range, migratory pathways and whelping locations of harp seals in the northwest Atlantic.

### 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 70,000 animals are taken during subsistence harvests, mainly in Greenland. Those catches consist primarily of animals aged 1+. The commercial harvest removed 289,500 seals in 2003 and 366,000 in 2004. Ninety-four percent of the commercial harvest consists of young of the year. An average of 5,000 seals is estimated to be removed incidentally during commercial fishing activities.

Subsistence harvests are currently not regulated while the commercial harvest was regulated by a three year management plan that ended in May 2005.

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 previous survey of pup production occurred in 1999 and an estimate of total abundance of this population was produced in 2000. New aerial surveys were carried out in 2004 and as a result, a new estimate of total population is available.

## SUMMARY

- Northwest Atlantic harp seals are harvested in Canadian and Greenland waters. After averaging approximately 52,000 seals per year between 1983-1995, reported Canadian catches increased significantly to a range of 240,000 to 366,000 between 1996 and 2004. Greenland catches have increased steadily since the mid 1970's reaching a peak of over 100,000 in 2000. They subsequently declined and have remained just under 70,000 since 2003. A recent study indicates that 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. Total removals have averaged approximately 468,500 seals annually since 1996. In 2004, 543,000 harp seals were estimated to have been removed.
- 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). Pup production has not changed since the last estimate in 1999.
- 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 and is currently at its highest level since the current time series began. Due to the large harvests in recent years, the population has been relatively stable since 1996.
- The estimated population size of northwest Atlantic harp seals for 2004 is 5.9 million (95% confidence interval 4.6 – 7.2 million). When using the same model and new data added in 2004, the population size in 2000 is estimated to have been 5.5 million. The difference seen between the current population estimate and that obtained in the last assessment is small compared to the uncertainty in these estimates.
- 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.

## DESCRIPTION OF THE ISSUE

The current three year management plan that regulates harvesting of harp seals in Canada expires prior to the 2006 hunting season. Aerial surveys of harp seal pup production were carried out in 2004 and new information was obtained on recent reproductive rates and the numbers of animals removed. The relevant information was incorporated into a population model and resulted in the production of a new report on the status of the population to be used in the development of a new management plan.

## **Species Biology**

The northwest Atlantic population of harp seals, historically the largest, 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.

## **The Hunt**

Harp seals have been hunted commercially since the early 18<sup>th</sup> 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 – 600,000 throughout the remainder of the 1800s, averaging 360,000 from 1818 – 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.

The first TAC was set in 1971 at 245,000 and varied until 1982 when it was set at 186,000 and remained the same until 1996 (Table 1). 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. 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 655,483 animals were taken in the first two years of this plan. Young of the year seals, that have moulted their whitecoat ('beaters') make up the vast majority of the recent Canadian catch, averaging approximately 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 1972-2004.

	1972-82	1983-95	1996	1997	1998	1999	2000	2001	2002	2003	2004
TAC	167 <sup>1</sup>	186	250	275	275	275	275	275	275	350 <sup>3</sup>	350 <sup>3</sup>
Catch	165 <sup>2</sup>	52 <sup>2</sup>	242	264	282	244	92	226	312	289	366

<sup>1</sup> Average TAC over time period, varied from 127 – 245.

<sup>2</sup> Annual Average catches.

<sup>3</sup> Maximum annual catch under the three year management plan, totalling 975.

Harp seals are also hunted in the Canadian Arctic and Greenland. Catches of harp seals in the Canadian Arctic have not been well documented, but during the late 1970's catches were thought to range between 1,200 and 6,500 (Figure 2). Until recently catches were thought to be in the order of 5,000 seals. However, a new study indicates that catches in Nunavut averaged 715 seals between 1997 and 2001. In addition, a small number of harp seals are taken in other areas of the Canadian Arctic (Nunavik and Labrador).

Prior to 1975, catches in Greenland were consistently less than 20,000 animals. From the mid 1970s up to 1996, catches increased from approximately 7,000 in 1975 to over 100,000 in 2000 (Figure 2). Reported catches declined in 2001 to 90,000 and have remained just under 70,000 since 2002.

The age structure of seals caught in the Canadian Arctic and Greenland is not well documented although a greater proportion of older (i.e. 1 year of age and older) seals are taken than in the Canadian commercial hunt.

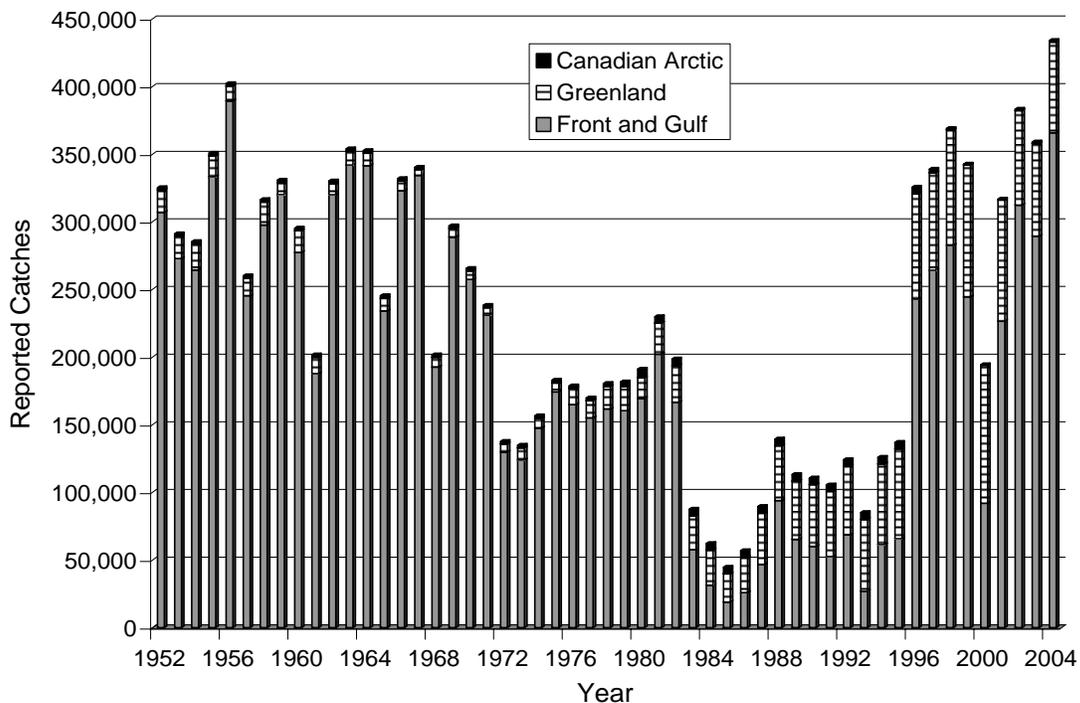


Figure 2: Reported commercial and subsistence catches of harp seals in the northwest Atlantic 1952-2004. Totals do not include seals killed but not landed or those killed as bycatch in commercial fisheries.

## **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 for the 1972-1982 period. 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. With higher levels of catches in both Canada and Greenland, total removals increased significantly after 1996 (averaging over 468,500 between 1996 and 2004) reaching levels similar, or slightly higher to, that estimated for the 1950s and 1960s. The single largest removal in the time series (543,000) occurred in 2004 although it remains lower than the peak catches (>600,000) the population was subjected to in the first half of the 19th century.

## **ASSESSMENT**

### **Resource Status**

The total number of harp seals in the northwest Atlantic cannot be counted directly. Surveys of the total population are impractical because harp seals are distributed widely across the Arctic and north Atlantic during the summer and, even though they congregate during the whelping and moulting periods, not all of the population is present at the surface at any one time and place. However, the number of harp seal pups born in a year can be estimated from aerial surveys conducted in the spring, when the seals gathered to have their pups. Therefore, estimates of total population are based on a population model that incorporates independent estimates of pup production with data on reproductive rates (the age of sexual maturity and the proportion pregnant each year) and catches including Canadian and Greenland harvest, bycatch and struck and lost.

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, of the Front and Gulf of St. Lawrence flown during the 1990's estimated a pup production of 580,000  $\pm$  78,000 pups in 1990, 703,000  $\pm$  125,000 in 1994 and 998,000  $\pm$  200,000 (rounded to the nearest 1000s) in 1999 (Figure 3).

### 2004 Pup Production

The most recent estimate of harp seal pup production in the Gulf of St. Lawrence and at the Front was obtained from surveys conducted by the Department of Fisheries and Oceans in March 2004. Extensive reconnaissance flights were carried out to find the whelping concentrations, monitor their movements and ensure that no major concentrations were missed. Both visual and photographic surveys were conducted to estimate pup production. Surveys of four whelping concentrations resulted in an estimated pup production of 640,800 ( $\pm$  91,900) at the Front, 89,600 ( $\pm$  44,100) in the northern Gulf and 261,000 ( $\pm$  50,400) in the southern Gulf (Magdalen Islands) for a total of 991,400 ( $\pm$  114,100) (Figure 3). Surveys were corrected for the number of pups estimated to have been born after the surveys were conducted and for the fraction of pups not detected on the photographs by readers.

Total pup production has increased throughout the 1980s and 1990s (Figure 3). However, this increase has stopped and the 2004 estimate did not significantly differ from that estimated in 1999 (997,900  $\pm$  200,100). This leveling off of pup production is due, in part, to the increased catches of young seals since 1996. The recent estimate is consistent with previous model predictions.

In 2004, the distribution of whelping animals was similar to the historical pattern, with two large groups at the Front corresponding to the traditional 'north' and 'south' concentrations. A small group was observed in the northern Gulf of St. Lawrence and another larger whelping concentration in the southern Gulf near the Magdalen Islands. 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. Teeth are removed from jaws and the ages determined by reading lines within the teeth.

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 uncertainty in estimates of total population size. The model incorporates data on pup production since the late 1970's, reproductive rates since 1960 and human induced mortality (catches, by-catch in fishing gear and struck and lost) since 1952.

The population model indicates that pup production increased relatively steadily from the early 1970s although the rate of increase has declined recently. A slight leveling of pup production was also seen in the late 1980s, reflecting lower pregnancy rates (Figure 3).

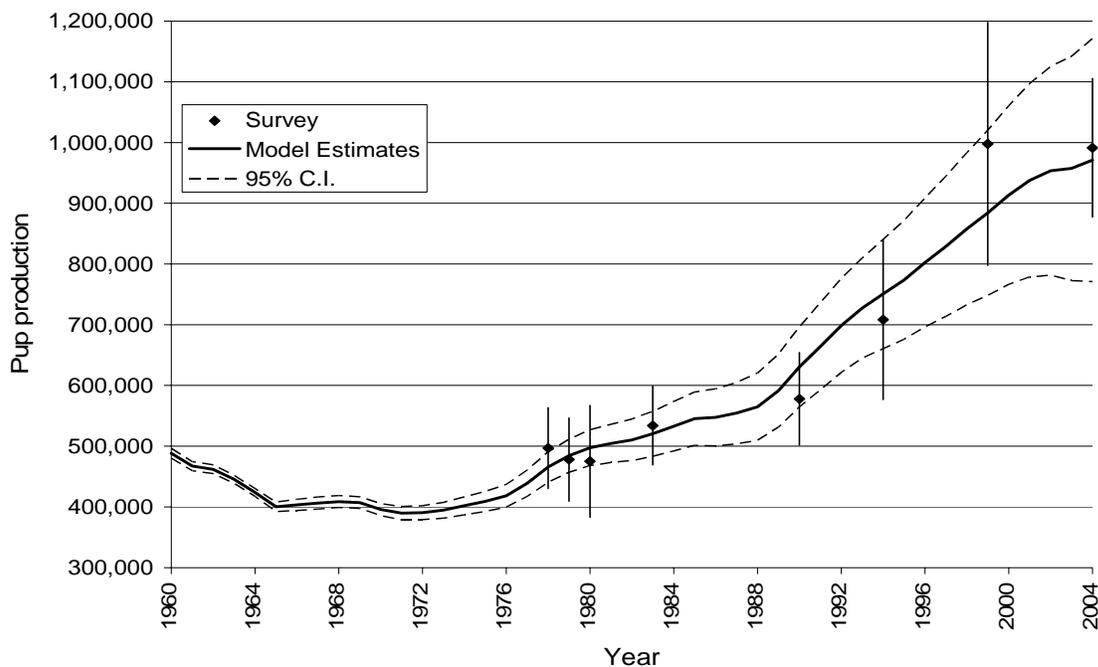


Figure 3: Independent survey estimates (bars indicate 95% confidence intervals) and model estimates of pup production 1960-2004.

Estimates of the total population declined during the 1960's, reached a minimum in the early 1970's, and then increased steadily until 1996 (Figure 4). 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 estimated total population size in 2004 is 5.9 million (95% Confidence Intervals 4.6 – 7.2 million) harp seals.

The uncertainty associated with the estimates of pup production and reproductive rates 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.

Incorporating new data into the population model resulted in slight changes to our estimates of total abundance. For example, the addition of the 2004 pup survey data resulted in a slight upward revision to our estimate of the population size in 2000 to 5.5 million (95% CI 4.5 – 6.4 million) instead of the estimate of 5.2 million (95% CI 4.0 – 6.4 million) animals which was based upon information available in 1999. This difference is not significant (within the range of uncertainty associated with these estimates). Such changes resulting from the addition of new data commonly occurs in science.

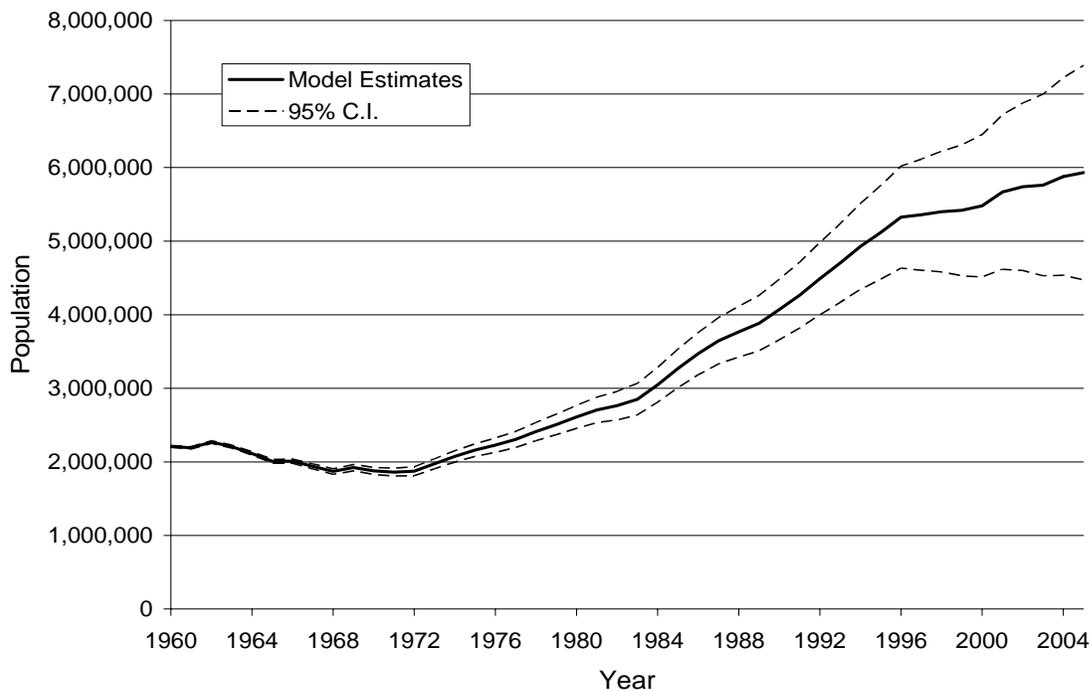


Figure 4: Estimates of total population 1960-2004.

### **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. Since then, they have declined by approximately 30%. 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.

Estimates of struck and loss are difficult to obtain. Current estimates are based on limited data that have been broadly applied. This will have little effect on estimates of total abundance if the struck and loss levels applied to each harvest area are relatively constant, and if rapid non-detected changes in the age composition of the harvest do not occur.

The age structure of the landed catch in Greenland and the Canadian Arctic is poorly known and based on historical data. Recent estimates are not available. The age structure of the catches of seals 1 year of age and older (1+) in the Canadian commercial hunt are also obtained from relatively few samples in some years, but given the small number of these animals taken, this has little impact on the population estimates.

Revised smoothed estimates of pregnancy rates for 2000-2004 were not available when the new assessment was done. Model projections were developed by assuming that no change in reproductive rates had occurred since the last assessment. Raw data available at the meeting did not indicate any major changes in reproductive rates from those used in 2000. Thus incorporating new pregnancy rate estimates is unlikely to significantly affect the abundance estimates provided.

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 independent measures of the status of the harp seal population are the estimates of pup production. However, the majority (>65%) of the total removals (94 % of the Canadian commercial catches) consist of young of the year seals and therefore, the impact of these removals will not be reflected in pup production until the cohorts mature sexually at 5 or 6 years of age. Thus there may be lag of 10-15 years before changes are reflected in pup abundance. These long term impacts need to be considered in any management decisions regarding this population.

## CONCLUSIONS AND ADVICE

Recent estimates of pup production are very similar to those obtained in 1999. The population estimates resulting from these surveys indicate that Northwest Atlantic harp seal population has changed little in recent years and remains at its highest level estimated. The difference seen between the current population estimate and that obtained in the last assessment is small compared to the uncertainty in these estimates.

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.

Annual estimates of the percentage of mature females giving birth each year were lower in the mid 1990's than in the early 1980's and have remained at this lower level. These lower reproductive rates are expected to reduce the potential rate of increase in the population in the coming years.

Long-term predictions of population size of Northwest Atlantic harp seals are uncertain due to potential changes in reproduction and, variability in annual removals and mortality rates (e.g. due to climate change). Periodic estimates of pup production and annual monitoring of reproductive rates, removals and ice conditions are required to determine future trends. Management must also consider the longer term impacts of current harvest strategies and the ability of the population to recover under uncertain environmental conditions.

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) into model projections. However, this could be expanded and an approach to modeling this population using Bayesian methods should be considered for the next assessment of this population.

This approach incorporates uncertainty more effectively and can use information on model elements that are not quantitative, such as expert opinion or traditional ecological knowledge. As such, it offers the potential to provide greater insight into the effects of changes in input data on the estimates of the dynamics of the seal population.

## OTHER CONSIDERATIONS

The 2003-2005 management plan expired in May 2005 and a new management plan is required before the 2006 Canadian hunt begins. This new information on abundance and population parameters will be incorporated into predictions estimating the impact of proposed management decisions.

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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