CLIMATE CHANGE AND SEAL POPULATIONS IN CANADA

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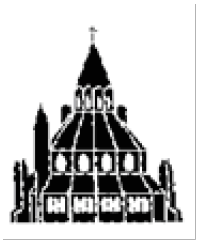

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INTRODUCTION

Seals, sea lions and walruses are pinnipeds (animals with fin-like flippers) of the taxonomic order *Carnivora*, which also includes bears, dogs, raccoons, and weasels. Pinnipeds are most diverse and numerous at high latitudes. In fact, the habitat of most pinniped species in Canada includes ice floes or ice sheets in the Arctic Ocean and Sub-arctic Seas. The Latin name for the harp seal, *Pagophilus*, means "ice-loving." Many species of pinnipeds use sea ice as a substrate for resting, breeding, whelping and molting. Moreover, many species are also migratory. For example, harp seals undertake long migrations (approximately 8,000 km round trip) to feed intensively on arctic cod in northern Baffin Bay and the eastern Canadian archipelago.(1)

Climate change in the Polar Regions is expected to be among the greatest of any region on Earth. The Arctic in particular is extremely vulnerable to climate change, and major physical, ecological, and economic impacts are expected to appear rapidly. Scientific experts predict that climate change will induce temperature changes and associated adjustments in ocean circulation, ice coverage and sea level.(2) In particular, the sea ice dynamics in northern and eastern Canada could have serious consequences for seal species that migrate through these waters and whelp in the Gulf of St. Lawrence and off Newfoundland.(3) This includes the harp seal, which is the main target of the Atlantic seal harvest, an important economic activity for many coastal communities on the East Coast. Also affected would be species such as the ringed seal, which are harvested by Aboriginals in the North mostly for subsistence purposes.

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(1) C.T. Tynan and D.P. DeMaster, "Observations and predictions of Arctic climate change: potential effects on marine mammals," *Arctic*, Vol. 50, No. 4, 1997, pp. 308-322, available at: http://proquest.umi.com/pqdweb?did=391992381&sid=1&Fmt=3&clientId=3485&RQT=309&VName=PQD, accessed 3 July 2007.

(2) Mark P. Simmonds and Stephen J. Isaac, "The impacts of climate change on marine mammals: early signs of significant problems," *Oryx*, Vol. 41, No. 1, 2007, pp. 19-26.

(3) Johnston, D. W. Friedlaender, A. S. Torres, L. G. Lavigne, D. M., "Variation in sea ice cover on the east coast of Canada from 1969 to 2002: climate variability and implications for harp and hooded seals," *Climate Research*, Vol. 29; No. 3, 2005, pp. 209-222.

This paper will review the known impacts of climate change on marine mammals, particularly the seal populations inhabiting Canadian waters. Focusing on the situation of the Atlantic seal harvest and the events of the 2007 season during which poor ice conditions were observed in the Gulf of St. Lawrence, scenarios for the seal harvest in future years are presented and the socio-economical consequences on the seal industry and the communities supporting the activity are discussed.

BRIEF DESCRIPTION OF PINNIPED SPECIES IN CANADA

There are three recognized families of pinnipeds:(4)

- earless or true seals, including elephant and harbour seals;
- eared seals, including fur seals and sea lions; and
- walruses.

There are ten species of seals identified in the *Marine Mammal Regulations* (MMR):(5)

- Bearded (*Erignathus barbatus*)
- Grey (*Halichoerus grypus*)
- Harp (*Pagophilus groenlandica*)
- Hooded or Hood (*Cystophora cristata*)
- Ringed or Jar (*Phoca hispida*)
- Harbour (*Phoca vitulina*)
- North Pacific fur (*Callorhinus ursinus*)

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(4) For statistical purposes, seals are often separated into two groups: fur seals and hair seals. While fur seals refer to a sub-group of eared seals, hair seals are earless seals.

(5) The seal harvest is regulated by the *Marine Mammal Regulations* (MMR). (5) The MMR were made pursuant to the *Fisheries Act* to manage and control fishing for marine mammals and related activities in Canada or in Canadian fisheries waters. The Regulations were consolidated in 1993, replacing the *Beluga Protection Regulations*, the *Cetacean Protection Regulations*, the *Narwhal Protection Regulations*, the *Seal Protection Regulations*, and the *Walrus Protection Regulations*. *Marine Mammal Regulations*, SOR/93-56, Schedule I, available at: http://laws.justice.gc.ca/en/F-14/SOR-93-56/index.html, accessed 3 July 2007.

- Northern elephant (*Mirounga angustriostris*)
- California sea lion (*Zalophus californianus*)
- Steller sea lion (*Eumetopias jubatus*)

Six species of seals – the harp, hooded, grey, ringed, bearded and harbour – are found off the Atlantic coast of Canada, although the bearded and the ringed seals have a circumpolar distribution that extends to the southern coast of Alaska. The coastal waters of British Columbia are home to the last five species of the list.

A. Harp Seal

There are three recognized populations of harp seals in the north Atlantic: the Northwest Atlantic population off Canada and western Greenland, which is the largest, breeds in the Gulf of St. Lawrence (the "Gulf") and off the southeast coast of Labrador and the northeast coast of Newfoundland (the "Front"), the east Greenland population which breeds near Jan Mayen Island (the "West Ice"), and the Barents Sea population which breeds in the White Sea (the "East Ice"). In the Gulf there are two whelping patches, the majority of harp seals being born on the ice near the Magdalen Islands (Southern Gulf patch) with smaller numbers born in the Northern Gulf (known as the "Mecatina" patch).

The harp seal is the most abundant pinniped in the Northwest Atlantic. The Northwest Atlantic population increased steadily from about 1.9 million in 1970 to almost 5.2 million in 1995. According to a 2005 estimate, this population stands at 5.8 million.[6] Harp seals are harvested commercially and for subsistence purposes in Canada, Greenland, Norway and Russia. The Canadian harvest of Northwest Atlantic harp seals is the largest marine mammal harvest in the world.

(6) M.O. Hammill and G. Stenson, Abundance of Northwest Atlantic harp seals (1960-2005), DFO, Canadian Science Advisory Secretariat, Research Document – 90, 2005, available at http://www.dfo-mpo.gc.ca/csas/Csas/Publications/ResDocs-DocRech/2005/2005_090_e.htm, accessed 3 July 2007.

B. Hooded Seals

Hooded seals are the second most commercially important species in Atlantic Canada. There are two whelping areas for hooded seals in Atlantic Canada: one in the Gulf of St. Lawrence and the other off Newfoundland and Labrador. The Gulf of St. Lawrence component is small (approximately 10,000 animals) and hunting of this herd is prohibited. Based on the last surveys conducted in 2005, total abundance of hooded seals was estimated to be between 547,000 – 603,000 animals.

C. Grey Seals

The grey seal is much larger than the harp seal. Grey seals are present and feed in the Gulf and on the Scotian Shelf year round. There are two grey seal herds, with the main breeding concentrations being in the southern Gulf of St. Lawrence and on Sable Island, Nova Scotia. The grey seal herd was surveyed in April 2004 and the population was estimated to be about 250,000 animals. Probably about two-thirds of the population is on the Scotian Shelf and one-third in the Gulf of St. Lawrence.(7)

D. Ringed Seals

The ringed seal is an important species in the arctic marine ecosystem, being the main prey of the polar bear, and a major consumer of marine fish and invertebrates. There are five subspecies of ringed seal. The most numerous, the Arctic ringed seal, is found in all of the Arctic Ocean seas and the Bering Sea, ranging as far south as Newfoundland and northern Norway. There is no up-to-date accurate estimate of Arctic ringed seal abundance due to its widespread and remote distribution.(8)

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(7) Mike Hammill, *Evidence*, House of Commons Standing Committee on Fisheries and Oceans, 9 November 2006.

(8) Seal Conservation Society, *Ringed Seal*, available at: http://www.pinnipeds.org/species/ringed.htm, accessed 3 July 2007.

Ringed seals are primarily harvested throughout the Arctic for subsistence purposes: for food, dog food and for pelts for handicrafts and clothing. According to Fisheries and Oceans Canada (DFO), there are limited commercial opportunities for ringed seals on the Atlantic coast off Labrador. In 2001, the ringed seal harvest in Labrador was a little more than 2,000 animals.(9)

E. Bearded Seals

One subspecies of bearded seals is found in the western Laptev Sea, Barents Sea and North Atlantic Ocean as far south as the Gulf of St. Lawrence in the Western Atlantic and Norway in the Eastern Atlantic. A second subspecies inhabits the remainder of the Arctic Ocean, as well as the Bering and Okhotsk Seas, being found as far south as Hokkaido and, very occasionally, China. There is currently no up-to-date overall population estimate for bearded seals.(10)

F. Harbour Seals

The harbour seal is the most widely-distributed pinniped, inhabiting temperate and subarctic coastal areas on both sides of the North Atlantic and North Pacific Oceans. Population estimates are imprecise or unavailable for most areas in the harbour seal's range. The Western Atlantic subspecies is found from the eastern Canadian Arctic and Greenland down to New Jersey, individuals occasionally wandering as far south as Florida. There is no reliable population estimate for the small Greenland population, but the American and Canadian populations are thought to total about 60,000-70,000 seals. The Eastern Pacific subspecies population consists of an estimated 285,000 seals, distributed from the Pribilof and Aleutian Islands in Alaska as far south as Baja California.(11) In British Columbia, there was an estimated 108,000 harbour seals in 1996-1998 based on an extrapolation of the observed density of seals in surveyed areas to the entire province and on the relative distribution of historical bounty kills.(12)

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(9) Fisheries and Oceans Canada, *Atlantic Seal Hunt 2003-2005 Management Plan*, Ottawa, available at: http://www.dfo-mpo.gc.ca/seal-phoque/reports-rapports/mgtplan-plangest2003/mgtplan-plangest2003_e.htm, accessed 3 July 2007.

(10) Seal Conservation Society, *Bearded Seal*, available at: http://www.pinnipeds.org/species/bearded.htm, accessed 3 July 2007.

(11) Seal Conservation Society, *Harbour Seal*, available at: http://www.pinnipeds.org/species/harbour.htm, accessed 3 July 2007.

(12) Olesiuk, P., *An assessment of the status of harbour seals (Phoca vitulina) in British Columbia*, DFO, Canadian Science Advisory Secretariat, Research Document – 33, 1999, available at: http://www.dfo-mpo.gc.ca/csas/Csas/publications/ResDocs-DocRech/1999/1999_033_e.htm, accessed 3 July 2007.

G. Species Inhabiting Canada's West Coast

In addition to the harbour seal, the coastal waters of British Columbia are home to the North Pacific fur and the Northern elephant seals, as well as the California and the Steller sea lions. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has assessed the status of seal and sea lion species. Of the five Pacific species examined, only the Steller sea lion was considered of "Special Concern." That determination was made in November 2003. The other species were considered "Not at Risk," and the assessments were done between 1986 and 1999.

H. Walrus

The walrus, which is also a pinniped but not a seal or a seal lion, is also identified in the MMR (a walrus fishing licence is described). The walrus is the only living member of the *Odobenidae* family of pinnipeds and has two generally recognised subspecies. The Atlantic walrus (*O.r. rosmarus*) is found from the east Canadian Arctic eastwards to the Kara Sea. The Pacific walrus (*O.r. divergens*) is found in the north Pacific Ocean and in Arctic waters from the East Siberian Sea to the western Beaufort Sea, as well as in the Laptev Sea. Accurate data on walrus abundance are not available but the most recent rough population estimates have been 22,500 Atlantic walruses (6,000 in Norway and Russia, 12,000 in Canada and 4,500 in Greenland), and a minimum of 200,000 Pacific walruses in eastern Russia and the United States.[13]

CANADIAN HARVEST OF SEALS AND RELATED SPECIES

Of the six species found in Eastern Canada, harp and hooded seals account for almost all the seals harvested commercially. In 2007, a total allowable catch (TAC) of 270,000 harp seals was set. For hooded seals, the TAC was set at 8,200 for the Newfoundland and Labrador Front and the hunt remained closed in the Gulf of St. Lawrence.

The rapid growth of the harp seal population has allowed significant increases in the TAC set by the federal government and, as a result, in the annual harvest of harp seals. After

(13) Seal Conservation Society, *Walrus*, available at: http://www.pinnipeds.org/species/walrus.htm, accessed 21 June 2007.

a 1983 European ban on the importation of pelts from very young harp and hooded seals, the harvest off Canada's East Coast declined to less than 20,000 in 1985, and consistently remained below 70,000 until 1995. Since 1996, with the exception of 2000, annual catches have been above 200,000. In 2005, reported catches for the Gulf and the Front were at 324,000, and total catches for the Northwest Atlantic (including Greenland) were at almost 395,000. For 2006, the Canadian harp seal TAC was set at 325,000 animals for the commercial sector with an additional 10,000 for Aboriginal harvest, personal use, and the Arctic harvest. It appears that the reported catch for 2006 may have exceeded the TAC by some 19,000 animals or 6%.[(14)] The calculated sustainable yield[(15)] for the Northwest Atlantic harp seal population, last estimated at 5.8 million animals, is 250,000 animals. Harvest rates in at least the past five years have been above the sustainable yield.

A number of grey seals are also taken for commercial uses. The TAC for this species is currently set at 9,000 animals, divided between harvesters in the Gulf of St. Lawrence (2,000 animals) and on the Scotian Shelf (7,000 animals). In 2006, the harvest was much smaller than the TAC with close to 1,800 animals harvested.

There are no TACs or allocations currently set on ringed, harbour and bearded seals. Licenses and permits are used to control any commercial harvest of these seals. Small numbers of harbour and bearded seals are taken each year in the subsistence hunt in northern Atlantic areas. As for ringed seals, DFO stated in its 2003-2005 Atlantic Seal Hunt Management Plan that "in recent years, the ringed seal harvest in Labrador has been in the range of less than 2,000 animals per year." Ringed seals are however harvested throughout the Arctic for subsistence purposes. Aboriginal peoples and non-Aboriginal coastal residents who reside north of 53°N latitude can harvest seals for subsistence purposes without a licence. In Nunavut, hunting of seals and other wildlife is monitored by the Nunavut Wildlife Management Board under the 1993 land claims agreement. The government of Nunavut estimates the current rate of

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(14) For 2006, total catches were at 354,344 animals, 97.6% of which were beaters (stage of development of a young seal at around 25 days of age).

(15) Catch that can be removed over an indefinite period without causing the stock to be depleted. Government of Western Australia, Department of Fisheries, Glossary of fishing, fisheries, aquatic and marine terms, available at: http://www.fish.wa.gov.au/glossary/GlossaryPage09.php?00, accessed on 19 February 2007.

harvest of ringed seals at approximately 35,000 a year.(16) In 2006, Nunavut harvesters exported some 6,000 ringed seal skins.(17)

On the West Coast, seal and sea lions were used for food and clothing by coastal natives. In the earlier part of the 20th century and until the late 1960s, they were harvested commercially and their populations regulated by predator control programs.

A "bounty" offered by DFO for each harbour seal killed between 1913 and 1964 reduced populations of that species to about half historic levels. This "bounty" system in Canada was terminated in 1969. Harbour seals were also hunted for their pelts between 1962 and 1969.(18)

In 1970, harbour seals, northern elephant seals, and Steller and California sea lions were protected under the *Fisheries Act*. However, commercial fishermen were still allowed to shoot seals and sea lions to defend their catch and gear, but that exemption was eliminated in 1984.(19) Since 1970, the populations of several species have rebounded. Consequently, concerns among fishermen, who often view seals and sea lions as competitors for fish and as a source of damage to their gear and catch, have emerged. There is no current commercial harvest of seal and sea lions on the west coast.

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(16) Government of Nunavut, *Sealing in Nunavut*, Department of Economic Development and Transportation, available at: http://www.edt.gov.nu.ca/sealing/resource.htm, accessed 3 July 2007. This document also quotes articles produced in 1998 by the North Atlantic Marine Mammal Commission's (NAMMCO) Scientific Committee which provided data on ringed seal populations and harvest statistics. The general conclusion of these articles is that the total Canadian ringed seal harvest is between 50,000 and 60,000 from a population that exceeds 1.2 million.

(17) Evidence presented by Raymond Ningeocheak, Second Vice-President of Nunavut Tunngavik Incorporated, to the House of Commons Standing Committee on Fisheries and Oceans, available at: http://cmte.parl.gc.ca/cmte/CommitteePublication.aspx?SourceId=191498, accessed 3 July 2007.

(18) Olesiuk, P. and M. A. Bigg, *Marine Mammals in British Columbia*, 1984, available at: http://www.racerocks.com/racerock/rreo/rreoref/mmammals/sealsandsealions.htm, accessed 3 July 2007.

(19) Jamieson, G.S. and P.F. Olesiuk, *Salmon farm – Pinniped interactions in British Columbia: an analysis of predator control, its justification and alternative approaches*, Fisheries and Oceans Canada, Canadian Stock Assessment Secretariat, Research Document 2001/142, Ottawa, 2001, available at: http://www.dfo-mpo.gc.ca/csas/Csas/DocREC/2001/RES2001_142e.pdf, accessed 3 July 2007.

MANAGEMENT OF THE ATLANTIC SEAL HARVEST

The Objective Based Fisheries Management (OBFM) approach was adopted by DFO for the 2003-2005 Atlantic Seal Hunt Management Plan and will continue to be used in managing the harp seal population. As recommended by the *Eminent Panel on Seal Management*, it uses reference points and control rules to establish management measures for a fishery. The approach is designed in such a way that the harp seal population does not fall below the threshold of 4.1 million animals or 70% of the largest observed population.

It has been argued that the harp seal population may be affected in the next few years by a reduction trend of the ice cover during whelping in the Northwest Atlantic, particularly in the Gulf of St. Lawrence.(20) The diminished ice cover, a likely consequence of global warming, forces the seal pups into the ocean before they are strong enough to swim. The Canadian Ice Service's seasonal outlook for the winter 2006-2007 predicted a reduced ice cover in the Gulf of St. Lawrence, which now appears to have been confirmed. In 2003, Fisheries and Oceans Canada (DFO) estimated a high pup mortality rate in the Gulf of St. Lawrence because of the poor ice conditions.(21)

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(20) Greenpeace argues in a 2005 report that "if population estimates and projected trends under exploitation fail to take account of the likelihood of climate-related increased pup mortality (and hence a progressive failure of young to enter the breeding population 4-5 years later), the harp seal population could decline rapidly, perhaps even below threshold values, well before such declines could be reliably detected under current monitoring regimes." Paul Johnston and David Santillo, *Canadian Seal Hunt: No Management and No Plan*, Technical Note, Greenpeace International, The Netherlands, 2005, available at: http://www.greenpeace.org/raw/content/canada/en/documents-and-links/publications/canadian-seal-hunt-no-managem.pdf, accessed 3 July 2007.

(21) M. Hammill and G. Stenson, *Harvest Simulations for 2003-2006 Harp Seal Management Plan*, Research Document – 2003/068, Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, 2003, available at: http://www.dfo-mpo.gc.ca/csas/Csas/publications/ResDocs-DocRech/2003/2003_068_e.htm, accessed 3 July 2007.

SECTION I – IMPACT OF CLIMATE CHANGE ON MARINE MAMMALS

A. The 2001 Report of the Working Group II of the International Panel on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by the World Meteorological Organization and the United Nations Environment Programme (UNEP). It involves hundreds of research scientists from universities, research institutes, and government agencies from around the world. The IPCC is considered to be the only organization that has looked at the whole picture of climate change.

The IPCC Working Group II focuses on the impacts of projected climate change. The working group's report, *Climate Change 2001: Impacts, Adaptation, and Vulnerability*, is its contribution to the Third Assessment Report of the IPCC.

With respect to the Polar Regions, the IPCC WGII made the following statements:

- Climate change in Polar Regions is expected to be among the greatest of any region on Earth.
- The Arctic is extremely vulnerable to climate change, and major physical, ecological, and economic impacts are expected to appear rapidly.
- Twentieth century data for the Arctic show a warming trend of as much as 5°C over extensive land areas.
- Changes in climate that have already taken place are manifested in the decrease in extent and thickness of Arctic sea ice: the extent of sea ice has decreased by 2.9% per decade, and it has thinned over the 1978-1996 period.
- Natural systems in Polar Regions are highly vulnerable to climate change and current ecosystems have low adaptive capacity.
- Parts of the Arctic and Antarctic where water is close to its melting point are highly sensitive to climate change, rendering their biota and socioeconomic life particularly vulnerable. Adaptation to climate change will occur in natural polar ecosystems mainly through migration and changing mixes of species. This may cause some species to become threatened (e.g., walrus, seals, polar bears), whereas others may flourish (e.g., fish, penguins). Although such changes may be disruptive to many local ecological systems and particular species, the possibility remains that predicted climate change eventually will increase the overall productivity of natural systems in Polar Regions.

The Working Group's report also mentioned possible specific impacts of climate change that would affect water resources in North America. These include:

- In the sub-Arctic and Arctic portions of the continent:
  - Thinner ice cover, a 1 to 3 month increase in ice-free season, and increased extent of open water.
  - Changes in aquatic ecology and species distribution as a result of warmer temperatures and longer growing season.
- Changes in estuary salinity and ecology, and increased stress on salmon and other fish species in coastal British Columbia, Yukon, and Alaska.
- Shifts in fish species distributions and migration patterns in Eastern Canada and the Northeast United States.

The report further discusses the impacts of climate change on marine mammals and states that "marine mammals and seabirds are sensitive indicators of changes in ocean environments." According to the IPCC, "because global climate change is likely to have profound impacts on sea-ice extent and duration, it is in this habitat where the initial impacts on marine mammals may be first evident."(22)

Reductions in sea ice have been predicted to alter the seasonal distributions, geographic ranges, migration patterns, nutritional status, reproductive success, and ultimately the abundance of Arctic marine mammals.(23) For example, the reduced ice cover and access to seals would limit hunting success by polar bears and foxes, with resulting reductions in bear and fox populations. The extended ice-free seasons in the Arctic could prolong the fasting of polar bears, with possible implications for the seal population.(24)

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(22) IPCC, *Climate Change 2001: Impacts, Adaptation, and Vulnerability: Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, James J. McCarthy, Osvaldo F. Canziani, Neil A. Leary, David J. Dokken, and Kasey S. White (eds.), Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2001, 1042 p., available at: http://www.grida.no/climate/ipcc_tar/wg2/index.htm, accessed 3 July 2007.

(23) Tynan and DeMaster (1997).

(24) I. Stirling, N.J. Lunn, and JJ. Iacozza, 1999: Long-term trends in the population ecology of polar bears in western Hudson Bay in relation to climatic change. Arctic, 52(3), 294-306 cited in IPCC (2001).

B. Seals Species in the Arctic

Pinnipeds are adapted to the aquatic environment. However, for some critical aspects of their life cycle they rely on a solid surface. Many species of pinnipeds, including seals, especially those inhabiting regions covered by seasonal sea ice, rely on suitable ice for resting, foraging, pupping, and moulting.(25) These species are most vulnerable to predation out of the water where they give birth. Sea ice provides an area where the risk of predation is reduced. The surface area of seasonal sea ice in the Arctic represents on average 7 million km^2 in the summer and 14 million km^2 in the winter.(26)

Recent analyses have revealed trends over the past 20-30 years of decreasing sea ice extent in the Arctic Ocean coincident with warming trends. Climate change will have multiple negative and positive impacts on the ecology of seals, and the net effect for each species will be a complicated weighting of diverse effects.(27) The recent trends in sea ice extent in the Arctic Ocean and subpolar seas are nonuniform and highly complex, with interannual and decadal scale oscillations. Therefore, the direct and indirect effects on marine mammals are expected to vary geographically. Seal species that rely on suitable ice substrate may be especially vulnerable to such changes.(28)

Direct effects of climate change on arctic marine mammals include the loss of ice-associated habitat. Indirect effects include:

- alterations in the timing or patterns of migrations; and
- regional or seasonal shifts in prey availability.(29)

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(25) Kelly, Brendan P., "Climate change and ice breeding pinnipeds," in Walther, G.-R, Conradin A. Burga, and Peter J. Edwards (eds.), *"Fingerprints" of Climate Change: Adapted Behaviour and Shifting Species Ranges*, Kluwer Academic/Plenum Publishers, New York, 2001, pp. 43-55. Tynan and DeMaster (1997).

(26) Kelly (2001).

(27) *Ibid*.

(28) Tynan and DeMaster (1997).

(29) *Ibid*.

It should be noted that our knowledge of the impacts of climate change on seal species is limited. The few studies linking arctic marine mammals to climate change are often limited by inadequate time series of population counts. More detailed information on the ecology of those species could uncover mechanisms by which environmental change might positively or negatively affect individual populations or species.(30)

The loss of ice-associated habitat is well illustrated by the situation of the ringed seal. Seasonal sea ice, which covers 5% of the Northern Hemisphere, is habitat for several million ringed seals, the most numerous and widespread marine mammal in the northern hemisphere.(31) Ringed seals rely on both the duration of the ice cover and the total precipitation to create sufficient snow depth for the building of subnivean (under the snow cover) lairs.(32) The ringed seal pups are born and nursed in those lairs where they are concealed for most or all of the first two months of life. Earlier snowmelts may prematurely destroy subnivean lairs. If snow decreases in depth and melts earlier, ringed seal pups may be exposed at an earlier age to freeze-thaw cycles and predators such as the polar bear. Past observations show that when the lack of snow cover has forced birthing to occur in the open, nearly 100% of the pups have succumbed to predation.(33)

Many seal species are migratory. Migration timing and patterns can be affected by climate changes. Because marine mammal migrations are closely linked to the seasonal cycle of sea ice, shifts in the timing or pattern of onset or breakup of seasonal ice might affect the distributions and stock structure of these species. It has been observed that during periods of heavy drift ice advance, populations of ringed seals along the east coast of Greenland headed southward round to the west coast, whereas harp seals along the central coast of West Greenland moved further north.(34)

One of the questions regarding climate change and the effects on arctic marine mammals is whether a reduction of sea ice will increase productivity in a way that maintains suitable densities of important prey species, such as arctic cod. Changes in the availability of prey would affect the nutritional status, reproductive success, and geographic range of many seal species. The migration of harp seals is linked to the production of ice algae during the Arctic

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(30) Kelly (2001).

(31) *Ibid*.

(32) Tynan and DeMaster (1997).

(33) Kelly (2001).

(34) Tynan and DeMaster (1997).

summer as well the productivity at the edge of ice. Harp seals migrate to the Canadian archipelago during the open-water season where feeding aggregations are found in nearshore areas, where dense schools of arctic cod concentrate in late summer. The arctic cod is a pivotal species in the arctic food web, as evidenced by its importance as a prey item to belugas, narwhals, harp seals, ringed seals, bearded seals, and hooded seals. The productivity of the arctic cod is dependant upon algal blooms that occurs at the ice-edge every spring. Given the coupling between the ice-edge habitat and the prey of many seal species, scientists have speculated that a sufficient reduction in the extent of the ice edge, and its associated community, may have harmful consequences for marine mammals that have evolved with these unique systems.(35)

There are additional concerns related to the warming trend in the Arctic that could affect seal populations. These include:

- the potential for an increased burden of pollutants entering the arctic environment;
- the potential for an increased incidence of diseases;
- the effects of increased ship traffic, exploration, industrial activities, fisheries, and associated noise;
- increased freshwater runoff from continents due to increased precipitation, which may affect the biomass of ice algae, prey availability, ice formation, and the load of pollutants in the Arctic; and
- the synergistic effects of these factors.(36)

C. Seal Species in Eastern Canada

In subpolar regions, changes in the extent of available ice are also having an effect on seal populations. Harp seals and hooded seals have evolved to use seasonal sea ice in the Gulf of St. Lawrence and on the "Front," off Newfoundland's Northern peninsula. These species time the whelping period to coincide with seasonal sea ice cover. The availability of seasonal sea ice cover of sufficient quality and quantity could therefore have significant effects on reproductive success, neonatal survivorship and possibly adult survivorship in these species. The timing of the spring thaw is important for harp and hooded seals as variability in where and when sea ice degrades at whelping patches can have consequences for nursing or recently weaned pups. Young harp seal pups are generally poor swimmers and have limited blubber stores for insulation. Animals that are nursed on rapidly degrading sea ice may suffer from cold

(35) *Ibid*.

(36) *Ibid*.

stress or starvation if they must enter the water prematurely, greatly reducing their chance of survival.

One study has examined the variation of the ice cover on the east coast of Canada from 1969 to 2002, and its effect on harp and hooded seal populations. The authors have observed that sea ice cover varied cyclically during that time and exhibited a period of light ice years in the latter part of the study period (1996 and 2002).(37) These conditions have also prevailed since, poor ice conditions having been observed in 2005, 2006, and 2007. During light ice years, there was a rapid reduction in ice cover in the study area in the first or second week of March, a phenomenon that was not observed in heavy ice years. These changes occurred primarily in the Gulf, but also on the Front. Therefore, limited ice availability in these years may have had significantly increased neonatal mortality in harp and hooded seals.(38) This was in part confirmed by DFO scientists who estimated as much as 75% harp seal pup mortality in the Gulf of St Lawrence in poor ice years.(39)

D. The 2007 Ice Conditions and its Impact on theAtlantic Seal Harvest Management

Extremely poor ice conditions were observed in February, March and April 2007 in the southern Gulf of St. Lawrence. In mid-March 2007, DFO suggested that if weather conditions were to be poor in the last 2 weeks of that month, the pup mortality for the southern Gulf "patch" could be very high, possibly approaching 100%. Poor conditions have also been observed in 1998, 2000, 2002, 2005, and 2006. DFO scientists now expect that these repeated

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(37) Johnston, D. W. Friedlaender, A. S. Torres, L. G. Lavigne, D. M., "Variation in sea ice cover on the east coast of Canada from 1969 to 2002: climate variability and implications for harp and hooded seals," *Climate Research*, Vol. 29; No. 3, 2005, pp. 209-222. These authors have also tried to establish a correlation between the ice conditions in the Gulf of St. Lawrence and off eastern Newfoundland and a phenomenon called the North Atlantic Oscillation. Such correlation would be useful to forecast future ice conditions and alter seal harvest management conditions accordingly. The North Atlantic Oscillation or NAO is a fluctuation in atmospheric pressure in the Atlantic Ocean between the high-pressure system near the Azores and the low pressure system near Iceland, quantified in the NAO Index. The NAO is the dominant mode of winter climate variability in the North Atlantic region ranging from central North America to Europe and into much of Northern Asia. A positive NAO phase, defined as a stronger than usual subtropical high pressure centre and a deeper than normal polar low, results in more and stronger westerly winter storms crossing the Atlantic Ocean on a more northerly track. This phase produces warmer and wetter winters in the eastern USA and Europe, and colder and dryer winters in northern Canada and Greenland.

(38) *Ibid*.

(39) Hammill and Stenson (2003).

events and the ensuing unusual pup mortality could have an impact on the long-term productivity of the seal herd.(40)

Current DFO assessments assume an average mortality of 12% (range 0 to 30%) due to poor ice conditions.(41) However, the department might have to re-assess this percentage. The high pup mortality in the southern Gulf is predicted to result in the population reaching the threshold of 4.1 million animals by 2009, 1 year earlier than previously predicted.(42) The Objective Based Fisheries Management (OBFM) approach prescribes that conservation measures should be taken once the population has reached this threshold.

In 2007, there was shift observed in the harvesting effort from the Southern Gulf to the Northern Gulf. Based on pup production surveys carried out between 1990 and 2004, about 30% are born in the Gulf of St. Lawrence: 23% of the pups are born in the southern Gulf while 7% are born in the northern Gulf.(43) In 2004, 26% of total pup production occurred in the southern Gulf. DFO scientists are concerned that if harvesting in the Gulf is repeatedly directed disproportionately to the northern Gulf, targeting the seals belonging to the smaller Mecatina "patch," this could result in loss of this component.(44)

(40) Dr. Mike Hammill, Fisheries and Oceans Canada, Personal Communication, 1 June 2007.

(41) *Ibid*.

(42) *Ibid*.

(43) *Ibid*. About 70% of the pups are born in the Front.

(44) *Ibid*.

SECTION II – SOCIO-ECONOMIC IMPACT OF CLIMATE CHANGE ON SEAL HARVEST

Any analysis of the expected socio-economic impacts of climate change on the seal harvest is beset by a number of uncertainties (discussed in detail in Appendix A) which are compounded by a dearth of reliable and consistent data about the economic value and importance of the seal harvest for sealers and their communities.

Even the 2001 Report of the *Eminent Panel on Seal Management*, which spent months consulting stakeholders and studying seal populations and the economics of the seal industry said it "had difficulty in accessing consistent and accurate data on the economy value of the sealing industry to sealers as well as the product value of seals."(45)

There is an equally serious shortage of sociological analyses on the importance of the seal-harvest to individuals and their communities as well as on community-responses to the loss of the seal harvest (as occurred in the 1980s for example).

Given this profound state of uncertainty, the best way to proceed is to begin by discussing what is known with some certainty and then using these facts as a springboard for conjecture – educated guesses – about the likely social and economic impact of climate change.

A. Economic Profile of the Seal Harvest

There are three commercial seal harvests in Canada: one in Newfoundland and Labrador (an area known as the Front, on the eastern shores of the province), one in the Gulf of St. Lawrence (both Southern and Northern), and another in Nunavut. For the purposes of this discussion, the Southern Gulf is defined as an area that includes the Magdalen Islands and sealing areas in Cape Breton, Nova Scotia, Prince Edward Island and New Brunswick. The Northern Gulf is defined as the North Shore area in Québec and the Newfoundland Gulf area.

In Newfoundland and Labrador and the Gulf of St. Lawrence, sealers overwhelmingly harvest harp seals; in Nunavut, ringed seals are the main target of the harvest. Because these three regions are quite different, it is useful to break down what is known about the economic profile of the seal harvest into national and sub-national or regional levels.

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(45) Ian McLaren *et al*, *Report of the Eminent Panel on Seal Management*, p. 98.

1. National Perspective

DFO estimates that the landed value of harp seal pelts from the Atlantic coast for the 2006 season almost doubled to slightly more than $33 million because of a 77% increase in pelt prices (to $97 per pelt) due to strong foreign demand, especially from the Nordic countries (Norway and Finland).(46) In 2006, Canada exported $16.4 million worth of seal fur skins, almost four times as much it did in 2002.

This $33 million figure does not include value-added activities such as the extraction and sale of seal oil, which is rich in omega-3 fatty acids, the butchering and sale of meat products, the processing of pelts,(47) or the use of pelts for the production of coats, hats, mitts, or other clothing items. While there are no readily available data on the revenue from the sale of meat products, processing or other value-added activities, there are data which show that Canada exported almost $1.5 million worth of marine mammal oil in 2006, down from $1.8 million in 2004 but more than double the value of its 2004 exports.

2. Regional Perspective

Judging by landed value figures, the seal harvest accounts for a small percentage of Canada's gross domestic product (GDP), just 0.002% of the total GDP.

This obscures the fact that the seal harvest *is* important for the economies of affected regions and is certainly important for dozens of small communities in rural, remote and coastal Canada that depend on resource extraction for their economic well-being and that have few other options for earning income.

a. Newfoundland and Labrador Harvest

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(46) DFO, "Socio-economic impact of the Atlantic Coast seal harvest," 9 March 2006, http://www.dfo-mpo.gc.ca/seal-phoque/reports-rapports/facts-faits/facts-faitsSE_e.htm. As the Report of the Eminent Panel on Seal Management notes, DFO's landed-value estimates have for reasons not altogether clear traditionally been lower than those produced by Newfoundland and Labrador's Department of Fisheries and Aquaculture (DFA). For 2006 however, the DFA estimates that the sealing industry contributed approximately $30 million to harvesters' income, some $3 million less than the DFO estimate. This discrepancy may, however, be explainable if one assumes that the DFA's number refers solely to income earned by Newfoundland and Labrador based harvester (this is not clear in DFA's background documents). The International Fur Trade Federation, for its part, says that the landed value from seal harvesting in Newfoundland & Labrador and Québec for 2006 was $29.2 million, which appears to be the U.S. dollar equivalent of DFO's $33 million figure.

(47) According to DFO (*op cit)*, between six and eight plants have engaged in some form of processing of seal pelts (soaking, drying, and shaving) in recent years. Four of these plants are in Newfoundland and the remainder in Québec.

Newfoundland and Labrador is home to Canada's largest seal harvest, accounting for almost 92% of the total harvest. The bulk of this harvest occurs in the Front but significant harvests also take place in the Newfoundland Gulf.

According to Newfoundland and Labrador's Department of Fisheries and Aquaculture (DFA), the seal industry, including value-added activities, contributes some $55 million to the provincial economy or about two tenths of 1% of provincial GDP using 2006 figures.(48) DFA further estimates that some 6,000 individuals in Newfoundland and Labrador, or about 1% of the province's population and 2% of its labour force, derive some income from seal harvesting. DFO puts the figure at 5,000.

DFA cites evidence given by sealers that their income from the seal harvest can account for between 25-35% of total annual income. In some cases, sealers are also fishermen and the income derived from the seal harvest helps tide them over during downtime in the fisheries.(49)

Some communities are more dependent on income from the seal harvest than others. According to DFA (and DFO), at least seven of the province's coastal communities derive between 15% and 35% of their total earned income from sealing; another 37 derive 5% or more of their earned income from sealing activities.(50)

Many seal harvest-based communities are also disadvantaged. According to DFO (and DFA), the "top homeports for sealers have unemployment rates that are in excess of 30% higher than the national average."(51)

Table 1 below shows the evolution of landings and landed value for seals – for the years 1998 to 2005 in Newfoundland and Labrador.

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(48) Newfoundland and Labrador's Department of Fisheries and Aquaculture does not spell out exactly what economic activities are included in this $55 million figure, although clearly it includes the landed value of seal pelts plus a number of unspecified value-added activities.

(49) Newfoundland and Labrador's Department of Fisheries and Aquaculture.

(50) *Ibid*.

(51) DFO, *op cit*.

Table 1 – Landings, Landed Value and Implied Value per Pelt, Newfoundland and Labrador, 1998-2005

Year	Landings	Landed Value (nominal dollars)	Implied Value per Pelt
1998	275,000	$8,750,000	$31.82
1999	270,620	$7,500,000	$27.71
2000	90,000	$4,300,000	$47.78
2001	240,000	$8,400,000	$35.00
2002	294,000	$20,000,000	$68.03
2003	289,000	$12,139,000	$42.00
2004	326,065	$15,290,000	$46.89
2005	290,124	$15,709,000	$54.15
2006*	295,164	$28,630,908	$97.00

* Data for 2006 are Library of Parliament estimates derived using data supplied by DFO.

Source: Library of Parliament on the basis of statistics from the Newfoundland and Labrador Department of Fisheries and Aquaculture, Landings and Landed Value, 1998-2005, http://www.fishaq.gov.nl.ca/statistics/2005.stm.

Assuming that Newfoundland and Labrador sealers obtained a market price of $97 per pelt and using data provided by DFO, the 2006 seal harvest generated an estimated $28.6 million in direct revenue for Newfoundland and Labrador sealers.

b. Gulf of St. Lawrence Harvest

The Southern Gulf is where the effects of climate change, largely in the form of poor ice conditions, have been most pronounced in terms of their consequences on the seal population. By contrast, DFO describes the ice situation in the Northern Gulf as "good."(52)

In recent years, DFO has allocated the total allowable catch (TAC) on a roughly 70%-30% basis, with 70% going to the Front and the other 30% to the Gulf. In 2006, sealers took a total of 354,344 harp seals, or 19,344 animals more than the 2006 TAC of 335,000.(53) The over-harvesting took place entirely in the Gulf (mostly in the Northern Gulf) while the Front yielded 19,000 fewer seals than allowed.

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(52) "Minister Hearn Announces 2007 Management Measures for Atlantic Seal Harvest," 29 March 2007, available at: http://www.dfo-mpo.gc.ca/media/newsrel/2007/hq-ac13_e.htm.

(53) DFO, "Frequently Asked Questions About Canada's Seal Harvest," available at: http://www.dfo-mpo.gc.ca/seal-phoque/faq_e.htm.

DFO data show that the Gulf harvest produced about 140,607 harp seal pelts in 2006. Assuming these pelts fetched the same price as other pelts (i.e., $97 a pelt), this implies that the harvest was worth about $13.6 million for the Gulf of St. Lawrence sealing communities in 2006.

c. Nunavut Harvest

In 2006, Nunavut harvesters exported some 6,000 ringed seal skins and generated some $530,000 worth of income.(54) These figures do not include seals harvested for local food consumption and value-added production of seal-related products, which are considerably more important in Nunavut than in Newfoundland or the Gulf of St. Lawrence harvests.

According to a 2001 study for the Department of Indian Affairs and Northern Development on the dietary habits of two Nunavut communities,(55) country food (essentially wild game) accounted for about 16% of the caloric intake of residents of Repulse Bay and 26% of the caloric intake for residents of Pond Inlet. An earlier study of the Broughton Island Inuit population found that "country food" accounted for 29% of caloric intake.

While seal meat was *not* the most important source of country food in any of these communities, it did play a relatively important role in two of the communities for which data are readily available. In Pond Inlet, survey data suggest that seal meat, fresh or frozen, accounts for anywhere from 8.3% to 17% of daily country food consumption measured by weight,(56) while in Repulse Bay, seal meat accounted for about 12.3% of daily country food consumption in 1992.

According to the government of Nunavut "the replacement value of the food from the harvest of ringed seal is estimated at $5 million and the value of products made from sealskin [at] more than $1.5 million"(57) for the territory as a whole.

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(54) Evidence presented by Raymond Ningeocheak, Second Vice-President of Nunavut Tunngavik Incorporated, to the House of Commons Standing Committee on Fisheries and Oceans, available at: http://cmte.parl.gc.ca/cmte/CommitteePublication.aspx?SourceId=191498.

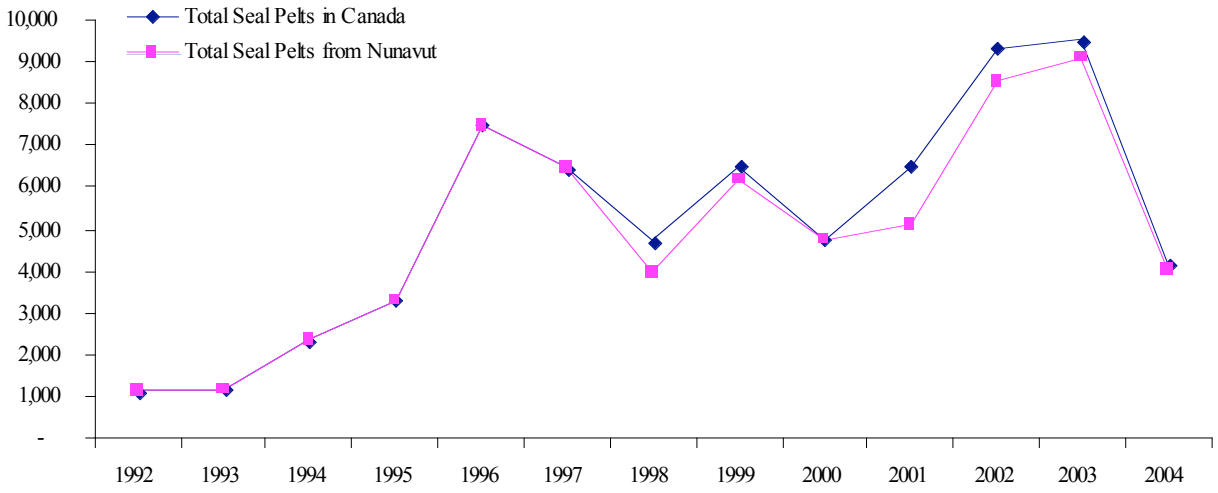
(55) Judith Lawn and Dan Harvey, *Change in Nutrition and Food Security in Two Inuit Communities, 1992 to 1997*, prepared for the Department of Indian Affairs and Northern Development, available at: http://www.ainc-inac.gc.ca/ps/nap/air/nutfoosec_e.pdf.

(56) This range represents results from three different surveys years, namely 1992 (8.3%), 1993 (17.2%), and 1997 (8.7%). Repulse Bay data on seal consumption were only available for 1992, when survey responses suggested that seal meat accounted for about 12% of total country food consumption.

(57) Government of Nunavut, "Sealing," available at: http://www.edt.gov.nu.ca/lookupnunavut/sealing.htm.

Figure 1 below depicts the evolution of the hair[58] seal harvest for Canada as a whole and for Nunavut in particular, with Nunavut accounting for between 96% and 100% of the harvest in any given year.[59] It also shows a sharp spike in the harvest in the mid-1990s followed by fluctuations, presumably dictated by price changes, over the ensuing years.

Figure 1 – Hair Seal Landings for Canada and Nunavut, 1992-2004



Source: Library of Parliament using data from Statistics Canada CANSIM Table 003-0013 and Statistics Canada, Fur Statistics 2005, Catalogue No. 23-013, Table 2-5.

B. Expected Socio-Economic Impact of Climate Change

In March 2007, the federal government reduced the total allowable catch for the 2007 harvest by 19.4% to 270,000. DFO retained however the broad objective of dividing the harvest on a 70%-30% Front/Gulf basis.

For the purposes of considering the longer-term impact of climate change on seal populations, harvests and sealing communities, it is instructive to consider three alternative scenarios for the seal harvest as shown in Tables 2a and 2b.[60] It is important to stress that these scenarios are speculative and based on somewhat arbitrary assumptions.

(58) See footnote no. 4.

(59) Note that the figure for 2001 appears suspect given the previous trends. It is also unclear why Statistics Canada would collect detailed statistics on the hair seal harvest in Nunavut (and elsewhere) but not do the same for the harp seal in Newfoundland or the Gulf of St. Lawrence.

(60) See Appendix A for a discussion of the uncertainties and assumptions that underlie these scenarios.

Table 2a – Harvest Quotas Under Three Scenarios

	Scenario 1: No Climate Change Impact		Scenario 2: Some Climate Change Impact		Scenario 3: Large Climate Change Impacts	
Year	**Front**	**Gulf**	**Front**	**Gulf**	**Front**	**Gulf**
2006	$232,657	$92,343	$232,657	$92,343	$232,657	$92,343
2007	$189,000	$81,000	$189,000	$81,000	$175,000	$81,000
2008	$175,000	$75,000	$175,000	$37,500	$145,000	$0
2009	$175,000	$75,000	$175,000	$37,500	$145,000	$0
2010	$175,000	$75,000	$175,000	$37,500	$145,000	$0
2011	$175,000	$75,000	$175,000	$37,500	$145,000	$0
2012	$175,000	$75,000	$175,000	$37,500	$145,000	$0

Table 2b – Impact of Scenarios on Sealing Revenue by Region, 2006-2012

	Scenario 1: No Climate Change Impact		Scenario 2: Some Climate Change Impact		Scenario 3: Large Climate Change Impacts	
Year	**Front**	**Gulf**	**Front**	**Gulf**	**Front**	**Gulf**
2006	$19,871,614	$13,638,879	$19,871,614	$13,638,879	$19,871,614	$13,638,879
2007	$18,333,000	$7,857,000	$18,333,000	$7,857,000	$16,975,000	$7,857,000
2008	$16,975,000	$7,275,000	$16,975,000	$3,637,500	$14,065,000	$0
2009	$16,975,000	$7,275,000	$16,975,000	$3,637,500	$14,065,000	$0
2010	$16,975,000	$7,275,000	$16,975,000	$3,637,500	$14,065,000	$0
2011	$16,975,000	$7,275,000	$16,975,000	$3,637,500	$14,065,000	$0
2012	$16,975,000	$7,275,000	$16,975,000	$3,637,500	$14,065,000	$0

Notes

1. The scenarios are constructed on the basis of somewhat arbitrary assumptions about the likely evolution of the quotas. In scenario 1, climate change has no permanent impact.

2. In Table 2a, the 2006 and 2007 harvest quotas represent actual DFO targets. Quotas for 2008-2012 were derived as per the scenario in question.

3. In Table 2b, data for 2006 are estimates of actual revenue based on actual harvests. Data for 2007 are estimated based on actual harvest quotas. Data for 2007-2012 are based on projections that assume a constant market price of $97 and that sealers harvest their full quota.

Source: Library of Parliament.

Scenario 1 starts from the premise that climate change has no long-term discernable impact on the Gulf or Front populations and that the recent problems with ice conditions are temporary. Beginning in 2008, DFO sets the harvest at what it has estimated to be a long-run sustainable level of 250,000 seals per year[(61)] and splits the quota on the usual 70-30 basis between the Front (175,000) and the Gulf (75,000). On the Front, sealing revenues fall by about 14% relative to 2006, although it is important to recall that the quotas in recent years were set at levels that DFO understood to be non-sustainable.[(62)] In the Gulf, revenues decline by almost half relative to 2006 largely because of over-harvesting (which drove up revenues) in 2006.

Scenario 2 assumes that the Gulf of St. Lawrence's harp seal population is permanently lowered by some combination of un-sustainable harvests in the Gulf and the effects of global warming; the Front's harvest is assumed identical to scenario 1. Beginning in 2008, DFO sets the Front's quota at 175,000 but lowers the Gulf's quota to 37,500 or half the level in scenario 1. The harvest is now split on an 82%-18% basis. The Front's sealing revenue falls by the same 14% (relative to 2006) as it did under scenario 1. In the Gulf however, sealing revenue declines by almost 75% relative to 2006. This time the decline is due to a combination of over-harvesting in 2006 *and* climate-change impacts on the seal population.

In scenario 3, DFO assumes that climate change impacts are likely to be severe, especially in the Gulf. Rather than risk losing the population altogether, it imposes an indefinite moratorium on sealing in the Gulf beginning in 2008. DFO also reduces the allowable catch on the Front by 15% below the levels in scenarios 1 and 2 to forestall any similar dynamic from taking place. On the Front, revenues fall by more than 29% due largely to climate change impacts. In the Gulf, sealing revenue falls to zero.

While these scenarios are speculative, there is evidence that the long-term productivity of the seal population in the Gulf is decreasing, with DFO scientists saying that pup mortality rates may have been close to 100% in 2007. Moreover, the early evidence indicates that the 2007 harvest yielded considerably less revenue than in 2006. This evidence is discussed next.

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(61) Technically, this harvest figure ensures that there is an 80% chance that the total harp population will remain above DFO's minimum target of 4.07 million.

(62) While DFO scientists established that the sustainable yield (sustainable harvest) for a population of 5.8 million animals was 250,000, the annual TAC in recent years has been set in excess of 325,000.

1. Newfoundland and Labrador

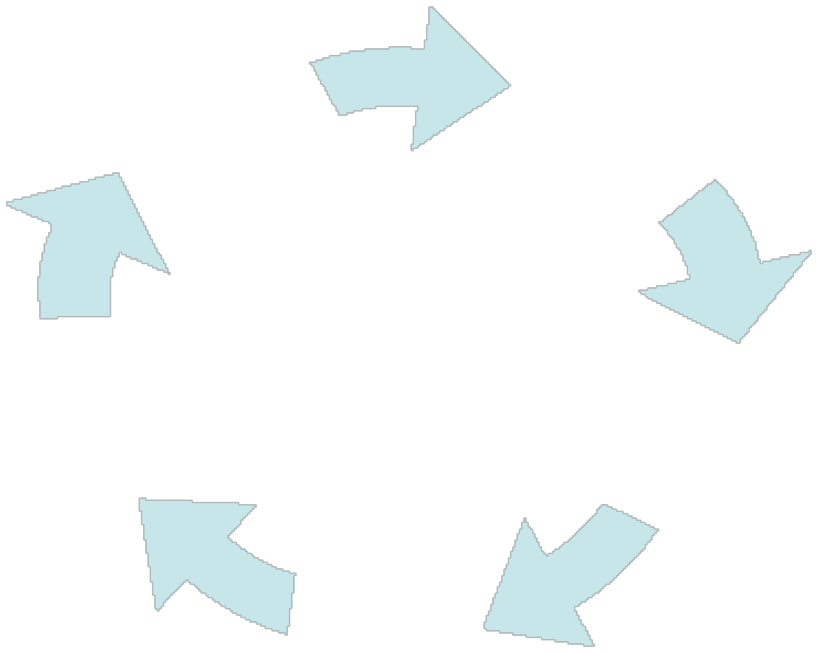
While final 2007 harvest data are not yet available, the 2007 TACs suggest that Newfoundland and Labrador sealers experienced a substantial decline in revenue relative to 2006. Specifically, the 2007 quotas reduced the allowable catch in Newfoundland's Front area by 5.6% to 193,284 relative to the 204,862 pelts harvested in 2006 and by 16.9% relative to the Front's 2006 TAC.

In dollar terms, and assuming this year's harvest maximized the quota, this implies that direct sealing revenue from the harvest on the Front fell by an estimated 5.2% to $18.7 million (assuming a market price of $97 per pelt). For the province as a whole (i.e., Front + Newfoundland Gulf harvest), the DFO's 2007 quotas imply a harvest of 246,985 seal skins worth about $23.9 million, or a 16.3% drop in revenue relative to 2006 (see Table 3).

Scenario 3 discussed above paints a quantitative picture (in dollar terms) of what might happen were these declines to persist. Qualitatively, persistent revenue declines could, for affected communities, eventually be reflected in weaker, less sustained economic activity (small business closures for example), worsening health outcomes (income and health are strongly correlated), population instability (more out-migration due to economic desperation), and less cohesive communities with weakened leadership (because of reduce out-migration and increased competition for scarce resources).

These outcomes could in turn produce other tangible consequences. Local schools would be more likely to close, as would local hospitals. At a minimum, class sizes might be expected to shrink and the range of hospital services to fall. Housing prices would also likely fall, weakening the financial security of homeowners. Finally the provincial government might be less willing to make long-term investments in local infrastructure, including items such as roads, sewers, water treatment, and wharves, with all the attendant consequences on well-being and quality of life. Figure 2 below illustrates what might be called a "typical" cycle of rural decline.

Figure 2 – Cycle of Rural Decline



2. Gulf of St. Lawrence

The reduced TACs for 2007 imply an estimated 31.1% decline in the Southern Gulf harvest to about 16,878 seal skins from 24,499 in 2006.(63) At a market price of $97 per pelt, this in turn implies a 31% or $739,246 drop in revenue to $1.6 million for Southern Gulf sealers. In the Northern Gulf, the implied decline is steeper still at almost 50% to about 59,838 seals or $5.8 million in revenue for 2007.

For the Gulf as a whole, sealing revenue fell by (an implied) 45% to $7.4 million. Early evidence from the 2007 harvest indicates that these (implied) figures are optimistic, with the Gulf hunt (Northern and Southern) believed to have yielded only 61,400 seals.(64) If so, this would suggest that sealing revenue in the Gulf fell by more than 56% to $5.96 million.

While it is difficult to say what portion of these declines can be attributed to climate change effects on the population, it is likely that at a substantial portion of the reduced quota (and catch) can be attributed to the realignment of the TAC with the current sustainable yield. The three scenarios discussed earlier shed some light on possible population and revenue trajectories in the medium term.

(63) Some of these seals may have been harvested in the Northern Gulf.

(64) Mike Hammill, Personal Communication.

To paint a fuller picture of the anticipated consequences of sharply reduced harvests on the Gulf's sealing communities, it is useful to look at the impact of the cod moratorium on Newfoundland coastal communities, especially if population declines in the Southern Gulf provoke a sudden closure of the harvest in that area as suggested in scenario 3. It should be noted however that the respective relative economic importance of the cod fishery prior to the moratorium and the current seal harvest are quite different.

In a study of the cod moratorium's affects on Bonavista, a small rural Newfoundland fishing community, researcher Peter Sinclair found an increase in the propensity for young people to leave the community following the crisis despite their strong attachment to the area.(65) He also documented some signs of a fraying cohesiveness in the community (people were more incline to behave in an individualistic fashion and less inclined to help each other out) and an increasing tendency of turning to the informal sector/informal economy.

These consequences are familiar. Consider for example this description of what one might expect to happen to a rural community that has lost a substantial part of its traditional income-generating economic base:

> A decline or transformation of the economic base of communities, for example, have typically led to reduced employment opportunities, more young people and young families moving to the city in search of employment, fewer infrastructural supports such as stores and retail services, and loss of local health care (Cotter, 2004; Gray, 1994 & Nelson, 1999). Research on the impact of these types of changes suggest that – what is most often referred to as the 'restructuring' of rural communities – affects individuals, households, and community relationships in varying ways, and can have profound impacts on the mental, physical and social health of individuals and communities (Fraser, 2005; Binkley, 2000; Neis & Grzetic, 2000; MacDonald, Phipps & Lethbridge, 2005). For example, traditional values, social and work relationships, and health-related practices are all affected by current restructuring processes and influence people's health and sense of well-being.

These effects would likely be amplified by the relative remoteness of many of the relevant sealing communities where distance to markets is compounded by limited access to economically interesting natural or human assets.

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(65) Peter Sinclair, "Leaving and Staying: Bonavista Residents Adjust to the Moratorium" in Rosemary E. Ommer, editor, *The Resilient Outport: Ecology, Economy and Society in Rural Newfoundland*, St. John's Newfoundland: Institute of Social and Economic Research.

3. Nunavut

It is unclear how climate change will affect the seal population off Nunavut. It is clear, however, that seals have been harvested for food, fuel, shelter and other products for hundreds of years by the Inuit. The subsistence harvest is a valuable link to the cultural heritage of Nunavut people, a fact recognized even by European countries that have otherwise taken a dim view of Canada's seal industry. According to the House of Commons Standing Committee on Fisheries and Oceans' recent seal harvest study:(66)

> For the Inuit, seals and sealing are part of a larger holistic view of their way of life. Inuit highly value and respect marine mammals such as the harp and the ringed seals. The witnesses explained that "marine mammals form an important part of Inuit nutrition and diet that comes from generations of living off the land and sea. Despite changes in today's world, the importance of marine mammals to Inuit remains as true as it ever was as a food source, a cultural source, a knowledge source, a spiritual and inspirational source, and a livelihood source." The Inuit told the Committee that whether it is in "terms of culture, tradition, knowledge, history, values, ethics, or modern practice, [they] have not and do not harvest their food and resource supply to depletion or to a level that would be considered irreversible to the species population.

Any reduction in the allowable catch or in the population for Nunavut would therefore have effects beyond the purely economic. They would also lead to an alteration of dietary habits, cultural practices, and perhaps even a phasing out of seal skin-based clothing.

C. Summary of Short-Term Impacts

Table 3 below summarizes some of the main (economic) points from the discussion, showing the expected economic impact of global warming and over-harvesting on 2007 revenue both in absolute terms and as a percentage of 2006 revenue for the three regions discussed as well as sub-areas within each region.

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(66) "Ensuring a Sustainable and Humane Seal Harvest," 4th Report of the House of Commons Standing Committee on Fisheries and Oceans (39th Parliament, 1st Session), available at: http://www.parl.gc.ca/fopo.

Table 3 – Estimated Economic Impact of Reduced Seal Harvest Due to Climate Change, by Region

	2006		2007		Expected Revenue Loss Due to Lower TAC	Expected Revenue Loss as a Percentage of 2006 Revenue
	Seal Harvest	Value of Harvest Assuming $97 per Skin	Estimated Harvest Based on TAC	Value of Harvest Assuming $97 per Skin		
Gulf	140,607	$13,638,879	76,716	$7,441,425	$6,197,454	45.4%
Southern Gulf	24,499	$2,376,403	16,878	$1,637,157	$739,246	31.1%
Magdalen Islands	21,755	$2,110,235	15,343	$1,488,237	$621,998	29.5%
Cape Breton/NS/PEI/NB	2,744	$266,168	1,534	$148,840	$117,328	44.1%
Northern Gulf	116,108	$11,262,476	59,838	$5,804,268	$5,458,208	48.5%
Newfoundland Gulf	90,302	$8,759,294	53,701	$5,208,990	$3,550,304	40.5%
Québec North Shore	25,806	$2,503,182	6,137	$595,279	$1,907,903	76.2%
Front	204,862	$19,871,614	193,284	$18,748,575	$1,123,039	5.7%
Newfoundland (Front + Northern Gulf)	295,164	$28,630,908	246,985	$23,957,564	$4,673,344	16.3%
Total	**345,469**	**$33,510,493**	**270,000**	**$26,190,000**	**$7,320,493**	**21.8%**

Source: Fisheries and Oceans Canada.

APPENDIX

APPENDIX

Any analysis that attempts to gauge the economic impact of climate change on the seal harvest must confront at least four overlapping layers of uncertainty. From these, several assumptions are made for the purposes of the analysis in Section II.

Uncertainty	Assumption for the purposes of Section II
Climate change uncertainty: as discussed in section I, the notion of climate change is bound up with mean (average) changes in global temperature. Some areas of the globe, including some areas of seal habitat, will experience more dramatic changes than others.	We can predict the direction and importance of climate change for each area. In the context of the analysis in Section II, we do not observe DFO's climate-change assumptions but they are implicit in its seal population assumptions, discussed below.
Population change uncertainty: even if we know the direction and amplitude of climate change for a given area, there remains a large degree of uncertainty over how the seal population will adapt, if at all.	We can predict the effect this climate change will have on seal population. This means that the population changes predicted by DFO are accurate.
Policy response uncertainty: even if we know the likely direction and size of climate change and its impact on seal populations, there is considerable uncertainty over the policy response to both anticipated and realized climate change and the impact these responses themselves might have on the population.	The government's policy response in the future will be roughly the same as in the past. In other words, it will continue with the 70%-30% Front/Gulf formula regardless of differences in climate change impacts in these regions. It is important to stress that this is the *opposite* of what one might have expected, namely a policy response that would be sensitive to the local impacts of climate change on the local population.
Socio-economic uncertainty: even if we know the response to all of the above forces, there is still a great deal of uncertainty over the future demand and price for seal skins, seal oil and seal clothing, all of which are affected by supply-side factors (climate change, seal population adaptability, willingness of seal harvesters to continue harvesting, policy changes) and demand-side factors (changes in consumer tastes, import bans, policy changes).	We can predict future supply and demand. In the context of the analysis below, we assume *status quo* prices – an equilibrium of sorts – for fur pelts and other products. This means that if there is a climate-change related decrease in the TAC (i.e., supply falls), demand falls proportionately to compensate and hold prices steady.