# BEFORE THE SECRETARY OF THE INTERIOR

# PETITION TO LIST THE POLAR BEAR (*Ursus maritimus*) AS A THREATENED SPECIES UNDER THE ENDANGERED SPECIES ACT

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CENTER FOR BIOLOGICAL DIVERSITY

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On the Cover: Message on the Wind – Polar Bear ©Thomas D. Mangelsen/Imagesofnaturestock.com

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The decades of research by so many members of the scientific community whose published work is cited herein are also gratefully acknowledged. Protection of the polar bear would not be possible without the hard and selfless efforts of the researchers and managers who have devoted their careers to the understanding and protection of this magnificent animal.

Authors: Kassie Siegel and Brendan Cummings, Center for Biological Diversity

## Executive Summary

*Introduction*

The polar bear (*Ursus maritimus*) faces likely global extinction in the wild by the end of this century as result of global warming. The species' sea-ice habitat is literally melting away. The federal Endangered Species Act ("ESA") requires the protection of a species as "Threatened" if it "is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." 16 U.S.C. § 1532(20) (emphasis added). A species is considered an "endangered species" when it "is in danger of extinction throughout all or a significant portion of its range." 16 U.S.C. § 1532(6). Unfortunately, the endangerment of the polar bear and its likely extinction are all too foreseeable, as both polar bear and climate scientists agree that the species cannot survive the ongoing and projected loss of its sea-ice habitat in a warming Arctic. Absent substantial reductions in emissions of greenhouse gases, by century's end average annual temperatures in the Arctic will likely rise upwards of 7° C (13.6° F) and summer sea ice will decline by 50-100%. The polar bear cannot survive such changes and therefore meets the statutory criteria for protection as Threatened under the ESA.

Petitioner, the Center for Biological Diversity, submits this Petition to the Secretary of the Interior and the United States Fish and Wildlife Service ("FWS") requesting formal protection of the polar bear as a Threatened species under the ESA. The ESA requires the Secretary and FWS to determine within 90 days of receiving the Petition whether the Petition "presents substantial scientific or commercial information indicating that the petitioned action may be warranted." 16 U.S.C. § 1533(b)(3)(A). Such determination is to be made solely on the basis of the "best available science." 16 U.S.C. § 1533(b)(1)(A). Following a positive "90-day" finding, the Secretary and FWS must within one year of receipt of the Petition complete a review of the status of the species and publish either a proposed listing rule or a determination that such listing is not warranted. 16 U.S.C. § 1533(b)(3)(B). The Secretary and FWS then have an additional year to finalize the proposed rule. 16 U.S.C. § 1533(b)(6)(A). In sum, assuming the Secretary and FWS comply with the statutory timelines of the ESA, the polar bear must be formally designated as a Threatened species within two years of the receipt of this Petition. Critical Habitat for the polar bear must also be designated concurrently with the species' listing as Threatened. 16 U.S.C. § 1533(a)(3)(A). Once the polar bear is listed under the ESA, all federal agencies are required to "insure" that any action they take does not jeopardize the continued existence of the species or destroy or adversely modify its critical habitat. 16 U.S.C. § 1536(a)(2). Listing under the ESA will have no effect on current Native Alaskan subsistence harvest of polar bears.

This Petition describes the natural history and biology of the polar bear, and the current status and distribution of the species. Next, the Petition reviews the primary threats to the continued existence of the polar bear, specifically how global warming will likely negatively and severely impact the species' habitat, prey, behavior, reproduction, and ultimately survival. The Petition also explains how existing law and regulations, both domestically and internationally, are inadequate to address these threats and prevent the endangerment and likely extinction of the polar bear. The Petition also details a host of additional threats to the polar bear, including oil and gas development in the Arctic, the accumulation of high levels of persistent organic pollutants such as PCBs in polar bear tissues, and unsustainable hunting practices, including illegal poaching, in some areas outside the United States. Global warming will likely also exacerbate some of these other threats. In sum, the Petition clearly demonstrates that the polar bear meets the legal criteria for listing as Threatened under the ESA and therefore the species must be promptly protected as such.

Scientists have been aware of global warming due to greenhouse gas emissions for over 30 years. That global warming is and will be more rapid and pronounced in the Arctic than in other areas of the world has been known and observed for nearly as long. Concern for the fate of the polar bear in a changing climate has been expressed for over a decade. However, in the past two years, with the release of the Arctic Climate Impact Assessment's ("ACIA's") report on *Impacts of a Warming Arctic* (ACIA 2004a), combined with a peer-reviewed analysis by three of the world's foremost experts on polar bears, *Polar bears in a warming climate* (Derocher, A.E., N.J. Lunn, and I. Stirling 2004), that the polar bear faces a very real likelihood of extinction in the foreseeable future cannot be dismissed as mere speculation. Rather, the "best available science" demonstrates that global warming is occurring, that Arctic sea ice is melting, and that absent significant reductions in human-generated greenhouse gases, such continued warming and consequent reduction of sea ice will occur that the polar bear will face severe endangerment and likely extinction in the wild by the end of the century.

*The "Best Available Science" on Global Warming*

That global warming as a result of anthropogenic greenhouse gas emissions (primarily carbon dioxide, methane, and nitrous oxides) is occurring and accelerating is no longer subject to credible scientific dispute. In 2001 the Intergovernmental Panel on Climate Change ("IPCC") released its *Third Assessment Report – Climate Change 2001*. The IPCC was established by the World Meteorological Organization and the United Nations Environment Programme in 1988. Its mission is to assess available scientific and socio-economic information on climate change and its impacts and the options for mitigating climate change and to provide, on request, scientific and technical advice to the Conference of the Parties to the United Nations Framework Convention on Climate Change. Since 1990, the IPCC has produced a series of reports, papers, methodologies, and other products that have become the standard works of reference on climate change (IPCC 2001a). The *Third Assessment Report* is the product of over 2000 scientists from 100 countries participating in the most rigorously peer-reviewed scientific collaboration in history. In its *Summary for Policymakers*, the IPCC (2001a:10) unequivocally stated that "[t]here is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities." The IPCC further concluded that:

> Projections using the SRES [*Special Report on Emissions Scenarios*] emissions scenarios in a range of climate models result in an increase in globally averaged surface temperature of 1.4 to 5.8°C over the period 1990 to 2100. This is about two to ten times larger than the central value of observed warming over the 20th century and the projected rate of warming is very likely to be without precedent during at least the last 10,000 years, based on paleoclimate data.

In the four years since the 2001 IPCC Report, the scientific consensus on global warming has only grown stronger (ACIA 2004a), and the warnings from climate scientists more urgent (e.g., Stott 2004; Stainford 2005;). While there is continuing scientific debate on specifics such as the rate or likely regional consequences of global warming, and while there are policy debates on what can and should be done to address global warming, the "best available science" clearly and unequivocally demonstrates that global warming is upon us and will bring profound changes to the world's climate over the course of this century and beyond.

*Global Warming's Impact on the Arctic*

Global warming is already having pronounced impacts on the Arctic. In November 2004 the Arctic Climate Impact Assessment's ("ACIA's") report on *Impacts of a Warming Arctic* (ACIA 2004a) was released. The ACIA is "a comprehensively researched, fully referenced, and independently reviewed evaluation of arctic climate change and its impacts for the region and for the world. It has involved an international effort by hundreds of scientists over four years, and also includes the special knowledge of indigenous people" (ACIA 2004a:v). The ACIA report concludes that greenhouse gas driven climate changes "are being experienced particularly intensely in the Arctic. Arctic average temperature has risen at almost twice the rate as the rest of the world in the past few decades. Widespread melting of glaciers and sea ice and rising permafrost temperatures present additional evidence of strong arctic warming" (ACIA 2004a:8). Significantly, "acceleration of these climatic trends is projected to occur during this century, due to ongoing increases in concentrations of greenhouse gases in the earth's atmosphere" (ACIA 2004a:8).

The ACIA's analysis and conclusions regarding Arctic temperature increases are dramatic. For example:

> In Alaska and western Canada, winter temperatures have increased by as much as 3-4° C (5-7°F) in the past 50 years. Over the next 100 years, under a moderate emissions scenario, annual average temperatures are projected to rise 3-5°C (5-9°F) over land and up to 7° C (13°F) over the oceans. Winter temperatures are projected to rise by 4-7°C (5-9°F) over land and 7-10°C (13-18°) over the oceans. (ACIA 2004b:2).

This ongoing and projected warming has already and will continue to severely reduce the extent of sea-ice coverage:

> Over the past 30 years, the annual average sea-ice extent has decreased by about 8%, or nearly one million square kilometers (386,100 square miles), an area larger than all of Norway, Sweden, and Denmark (or Texas and Arizona) combined, and the melting trend is accelerating. Sea-ice extent in summer has declined more dramatically than the annual average, with a loss of 15-20% of the late-summer ice coverage. Additional declines of 10-50% in annual average sea-ice extent are projected by 2100. Loss of sea-ice during summer is projected to be considerably greater, with a 5-model average projecting more than a 50% decline by late this century, and some models showing near-complete disappearance of summer sea ice. (ACIA 2004b:3).

In sum, the impacts of global warming on the Arctic are already being felt with a rise in temperature and a consequent decline in sea ice. Under relatively optimistic future emissions scenarios, summer sea ice will likely decline 50-100% by the end of the century. Under any scenario, the future of ice-dependent species such as the polar bear is grim.

*The Future of Polar Bears in a Warming Arctic*

Polar bears are completely dependent upon Arctic sea-ice habitat for survival. Polar bears need sea ice as a platform from which to hunt their primary prey (ringed seals, *Phoca hispida*), to make seasonal migrations between the sea ice and their terrestrial denning areas, and for other essential behaviors such as mating. Unfortunately, the polar bear's sea-ice habitat is quite literally melting away.

Canada's Western Hudson Bay population, at the southern edge of the species' range, is already showing the impacts of global warming. Break-up of the annual ice in Western Hudson Bay is now occurring on average 2.5 weeks earlier than it did 30 years ago. Earlier ice break-up is resulting in polar bears having less time on the ice to hunt seals. Polar bears must maximize the time they spend on the ice feeding before they come ashore, as they must live off built-up fat reserves for up to 8 months before ice conditions allow a return to hunting on the ice. The reduced hunting season has translated into thinner bears, lower female reproductive rates, and lower juvenile survival. While population declines are not yet evident in Hudson Bay, polar bear scientists calculate that if sea-ice trends continue, most female polar bears in the Western Hudson Bay population will be unable to reproduce by the end of the century, and possibly as early as 2012 (Derocher et al. 2004). Without reproduction, this population is doomed to extinction.

While Western Hudson Bay is the only population in which scientists have already observed negative impacts from climate change and published their results in peer-reviewed journals, impacts that have not yet been documented may be occurring in other less well-studied populations as well. Regardless, the consequences of future sea-ice reductions for polar bears globally will be severe. According to the ACIA, "the reduction in sea ice is very likely to have devastating consequences for polar bears, ice-dependent seals, and local people for whom these animals are a primary food source." (ACIA 2004b:1). The ACIA concludes that "<u>polar bears are unlikely to survive as a species</u> if there is an almost complete loss of summer sea-ice cover, which is projected to occur before the end of this century by some climate models….The loss of polar bears is likely to have significant and rapid consequences for the ecosystems that they currently occupy." (ACIA 2004a:58) (emphasis added).

A 2004 peer-reviewed analysis looking at all aspects of global warming's impacts on the polar bear by three of the world's foremost experts on the species, *Polar bears in a warming climate* (Derocher et al. 2004:163), came to a similar conclusion as the ACIA, stating that "it is unlikely that polar bears will survive as a species if the sea ice disappears completely as has been predicted by some."

Even short of complete disappearance of sea ice, projected impacts to polar bears from global warming will affect virtually every aspect of the species' existence, in most cases leading to reduced body condition and consequently reduced reproduction or survival:

- The timing of ice formation and break-up will determine how long and how efficiently polar bears can hunt seals. A reduction in the hunting season caused by delayed ice formation and earlier break-up will mean reduced fat stores, reduced body condition, and therefore reduced survival and reproduction.

- Reductions in sea ice will in some areas result in increased distances between the ice edge and land. This will make it more difficult for female bears that den on land to reach their preferred denning areas. Bears will face the energetic trade-off of either leaving the sea ice earlier when it is closer to land or traveling further to reach denning areas. In either case, the result is reduced fat stores and likely reduced survival and reproduction.

- Reductions in sea-ice thickness and concentration will likely increase the energetic costs of traveling as moving through fragmented sea ice and open water is more energy intensive than walking across consolidated sea ice.

- Reduced sea-ice extent will likely result in reductions in the availability of ice-dependent prey such as ringed seals, as prey numbers decrease or are concentrated on ice too far from land for polar bears to reach.

- Global warming will likely increase the rates of human/bear interactions, as greater portions of the Arctic become more accessible to people and as polar bears are forced to spend more time on land waiting for ice formation. Increased human/bear interactions will almost certainly lead to increased polar bear mortality.

- The combined effects of these impacts of global warming on individual bears' reproduction and survival are likely to ultimately translate into impacts on polar bear populations. Impacts will be most severe on female reproductive rates and juvenile survival. In time, reduction in these key demographic factors will translate into population declines and extirpations.

In sum, changes in sea-ice extent, thickness, movement, fragmentation, location, duration, and timing will have significant and often adverse impacts on polar bear feeding, breeding, and movement. Such impacts will likely result in reduced reproductive success and higher juvenile mortality, and in some cases increased adult mortality. By century's end the combined effects of these demographic changes will likely result in population declines and extirpations, and possible global extinction of the species.

Summarizing the various likely impacts of global warming on the polar bear, Derocher et al. (2004:172) come to the following sobering conclusion:

> In contrast to many terrestrial and most marine species that may be able to shift northward as the climate warms, polar bears are constrained in that the very existence of their habitat is changing and there is limited scope for a northward shift in distribution. Due to the long generation time of polar bears and the current pace of climate warming, we believe it unlikely that polar bears will be able to respond in an evolutionary sense. Given the complexity of ecosystem dynamics, predictions are uncertain but <u>we conclude that the future persistence of polar bears is tenuous</u>. (emphasis added).

In addition to the suite of impacts from global warming, polar bears also face additional threats such as increasing oil exploration and development and risk of oil spills throughout the Arctic, serious impacts to the immune system and reproductive system from exceptionally high levels of contaminants such as PCBs, unsustainable hunting and illegal poaching in some areas, and increased human activity in the Arctic. Global warming will likely interact with several of these additional threats in a synergistic and cumulative fashion, further increasing the polar bear's peril.

*Existing Legal Mechanisms are Inadequate to Address Global Warming and Prevent the Likely Extinction of the Polar Bear*

Global warming due to anthropogenic greenhouse gas emissions is the primary threat to polar bears, and also one of the most difficult threats to regulate. Despite the scientific consensus that global warming is in fact occurring, and will have dramatic effects across the world, greenhouse gas emissions continue to increase both globally and domestically. Existing regulatory mechanisms such as the United Nations Framework Convention on Climate Change and the Kyoto Protocol have to date been completely ineffective at actually reducing greenhouse gas emissions. At best, they have slowed the rate of increase. However, even if fully implemented, (an unlikely scenario given the United States, the world's largest emitter of greenhouse gases, has officially renounced the Kyoto Protocol) these mechanisms will not reduce greenhouse gas emissions sufficiently to avoid the warming of the Arctic and consequent adverse impacts to polar bears that are already occurring or will occur by the end of the century. As such, it is clear that existing regulatory mechanisms are inadequate to prevent the polar bear from becoming an endangered species in the foreseeable future.

The United Nations Framework Convention on Climate Change ("UNFCCC") was adopted in May 1992 at the first Earth Summit held in Rio de Janeiro, Brazil, and entered into force in March 1994 (Energy Information Administration ("EIA") 2004). The stated objective of the UNFCCC is the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system (EIA 2004). Due to the complexity of climate issues and the widely divergent political positions of the world's nation states, the UNFCCC itself was unable to set emissions targets or limitations, but instead created a framework that sets the stage for a range of subsequent actions (UNFCCC 2004). In other words, the UNFCCC is a mechanism for future agreements that might result in actual greenhouse gas emission reductions; it does not require any actual reductions in such emissions. As such, in and of itself, it is wholly inadequate to prevent further greenhouse gas emissions and consequent global warming.

In 1997 the Kyoto Protocol became the first additional agreement added to the UNFCCC to set emissions targets. The Kyoto Protocol set goals for developed countries only to reduce their emissions to at least 5% below their 1990 levels (UNFCCC 2004). Over seven years passed before the Kyoto Protocol entered into force on February 16, 2005 (UNFCCC 2005). While the entry into force of the Kyoto Protocol is an important symbolic first step in the necessary global response to climate change, it is inadequate to prevent sufficient build up of greenhouse gases to avoid significant warming of the Arctic and the consequent likely extinction of the polar bear. First, the Protocol's overall emissions targets are highly unlikely to be met, due in large part to the refusal of the United States to ratify the agreement. The United States accounts for approximately 24% of worldwide carbon dioxide emissions (EIA 2004). The Kyoto target for the United States was a 7% reduction in greenhouse gas emission levels from 1990 levels by 2012 (EIA 2004). According to the U.S. Government Accounting Office ("GAO"), between 1990 and 2001, United States emissions have in fact increased by 13%. Total United States emissions are projected to grow a staggering additional 43.5% through the period 2025 (GAO 2003a). The United States simply will not meet Kyoto targets by the Protocol's 2012 deadline. Without United States compliance, global Kyoto targets are unlikely to be met. Overall, the EIA estimates that worldwide carbon emissions in 2025 will exceed 1990 levels by 72% (EIA 2004).

Moreover, even in the unlikely event that overall Kyoto targets were fully met by the year 2012, the reductions are far too small to substantially reduce Arctic warming and consequent sea-ice reduction sufficiently to protect the polar bear. Implementation of the Kyoto Protocol would only slightly reduce the rate of growth of emissions – it would not stabilize them (Williams 2002). Carbon dioxide levels had risen to 379 ppm by March 2004, from pre-industrial levels of 280 ppm (International Climate Change Taskforce 2005). Stabilizing carbon dioxide concentrations at 440 ppm (23% above current levels) would require global emissions to drop below 1990 levels within a few decades, with emissions eventually declining to a very small fraction of current levels, despite growing human populations and an expanding world economy. These cuts will not be achieved simply by compliance with Kyoto (Williams 2002).

Most significantly, the ACIA projections of likely polar bear extinctions are based upon climate models that already assume future reductions in greenhouse gas emissions. Predictions of 50-100% loss of summer sea ice come from models using projected emissions levels that fall slightly below the average of possible scenarios. Actual impacts will likely be much greater. Only by implementing major cuts in greenhouse gas emissions in the very near future will a scenario be possible in which sufficient sea ice remains that the polar bear can persist as a species.

*Conclusion*

The future of the polar bear is indeed grim. While most populations are currently reasonably healthy and the global population is not presently endangered, the species as a whole faces the likelihood of severe endangerment and possible extinction by the end of the century. As such, it will be endangered in the foreseeable future and therefore meets the criteria for listing now as Threatened under the ESA. While the polar bear will likely not disappear for several decades, decisions made and actions taken over the next decade will likely dictate whether the species can survive. Only with prompt action to drastically reduce greenhouse gas emissions can the future of the polar bear be assured. The United States must play a leading role in this global effort. Listing the species under the ESA is a small but significant step in that direction.

## Notice of Petition

Pursuant to Section 4(b) of the Endangered Species Act ("ESA"), 16 U.S.C. §1533(b), Section 553(3) of the Administrative Procedures Act, 5 U.S.C. § 553(e), and 50 C.F.R. §424.14(a), Petitioner Center for Biological Diversity hereby petitions the Secretary of the Interior, through the United States Fish and Wildlife Service ("FWS"), to list the polar bear (*Ursus maritimus*) as a threatened or endangered species and designate critical habitat to ensure its recovery.

The FWS has jurisdiction over this petition. This petition sets in motion a specific process, placing definite response requirements on FWS. Specifically, FWS must issue an initial finding as to whether the petition "presents substantial scientific or commercial information indicating that the petitioned action may be warranted." 16 U.S.C. §1533(b)(3)(A). FWS must make this initial finding "[t]o the maximum extent practicable, within 90 days after receiving the petition." *Id.* Petitioners need not demonstrate that listing *is* warranted, rather, Petitioners must only present information demonstrating that such listing *may* be warranted. While Petitioners believe that the best available science demonstrates that listing the polar bear as threatened *is* in fact warranted, there can be no reasonable dispute that the available information indicates that listing the species *may* be warranted. As such, FWS must promptly make a positive initial finding on the petition and commence a status review as required by 16 U.S.C. § 1533(b)(3)(B).

The term "species" is defined broadly under the ESA to include "any subspecies of fish or wildlife or plants and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature." 16 U.S.C. § 1532 (16). A Distinct Population Segment ("DPS") of a vertebrate species can be protected as a "species" under the ESA even though it has not formally been described as a separate "species" in the scientific literature. A species may be composed of several DPSs, some or all of which warrant listing under the ESA. As described in this petition, the polar bear is currently recognized as a single species, *Ursus maritimus.* However, scientists also recognize twenty polar bear populations, each of which meets the criteria for designation as a distinct population segment under the ESA and FWS's "Policy Regarding the Recognition of Distinct Vertebrate Population Segments under the Endangered Species Act." 61 Fed. Reg. 4721. Additionally and alternatively, four polar bear population "clusters" have been described based on genetic analyses, and each of these four populations also qualifies as a distinct population segment. As such, each of the 20 separate polar bear populations and, alternatively, each population cluster constitutes a "species" under the ESA.

Therefore, Petitioners request that FWS evaluate whether the full polar bear species qualifies for listing as threatened or endangered. In the event that the FWS finds that this petition does not present substantial information indicating that listing of the full polar bear species may be warranted, Petitioners request that the FWS evaluate whether each of the 20 polar bear populations qualifies as a distinct population segment, and if so, if each qualifies for listing as threatened or endangered. Additionally, Petitioners request that the FWS evaluate whether each of the four polar bear population "clusters" described in the Petition qualifies as a distinct population segment, and if so, if each qualifies for listing as threatened or endangered. The scientific basis for the requested listing is set forth fully in the Petition.

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Respectfully submitted this 16th day of February, 2005

Kassie R. Siegel, Staff Attorney
Center for Biological Diversity
P.O. Box 493
Idyllwild, CA 92549
Tel: (951) 659-6053
Fax: (951) 659-2484
Email: ksiegel@biologicaldiversity.org

The Center for Biological Diversity ("Center") is a non-profit, public interest conservation organization dedicated to the protection of native species and their habitats through science, policy, and environmental law. The Center has over 11,000 members throughout the United States and internationally. The Center and its members are concerned with the conservation of endangered species, including polar bears, and the effective implementation of the Endangered Species Act.

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# Introduction

The polar bear (*Ursus maritimus*) faces likely global extinction in the wild by the end of this century as result of global warming. The species' sea-ice habitat is literally melting away. The federal Endangered Species Act ("ESA") requires the protection of a species as "Threatened" if it "is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." 16 U.S.C. § 1532(20) (emphasis added). A species is considered an "endangered species" when it "is in danger of extinction throughout all or a significant portion of its range." 16 U.S.C. § 1532(6). Unfortunately, the endangerment of the polar bear and its likely extinction are all too foreseeable, as both polar bear and climate scientists agree that the species cannot survive the ongoing and projected loss of its sea-ice habitat in a warming Arctic. Absent substantial reductions in emissions of greenhouse gases, by century's end average annual temperatures in the Arctic will likely rise upwards of 7° C (12.6° F) and summer sea ice will decline by 50-100%. The polar bear cannot survive such changes and therefore meets the statutory criteria for protection as Threatened under the ESA.

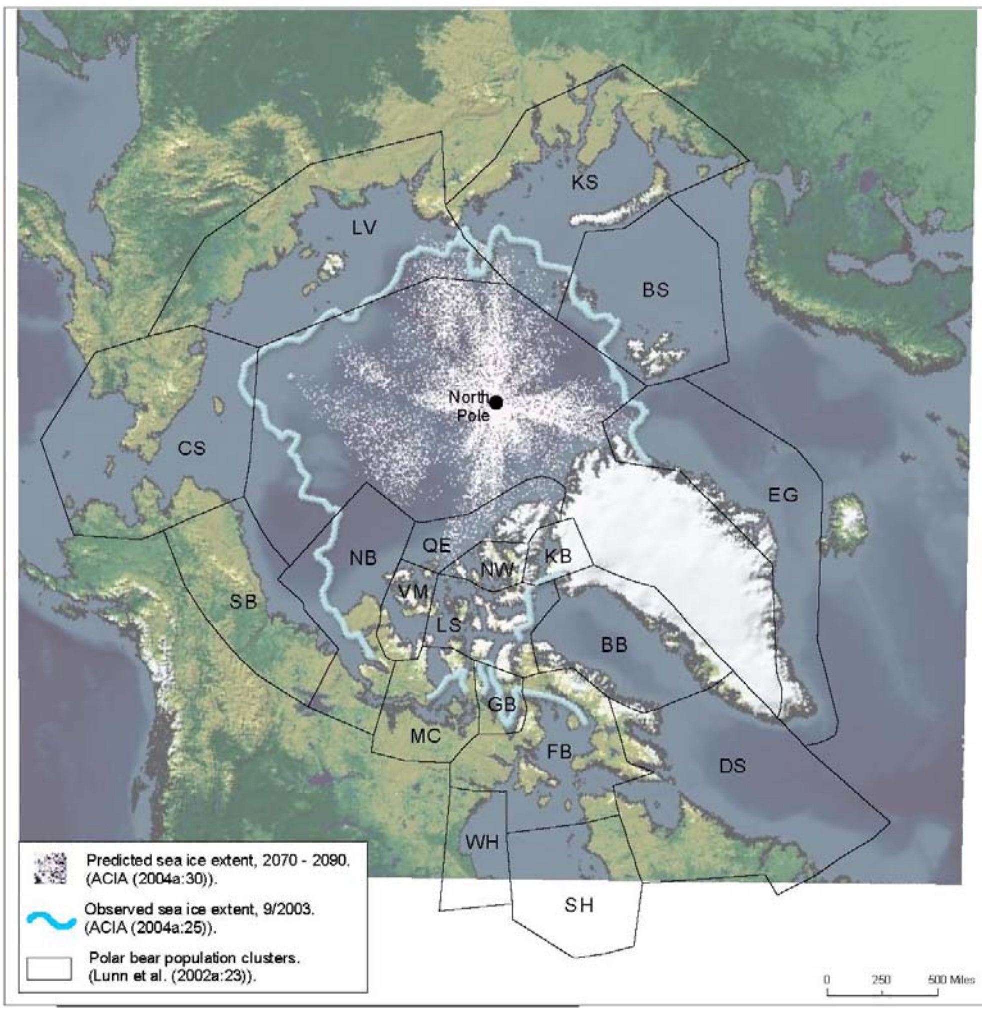
This Petition describes the natural history and biology of the polar bear, and the current status and distribution of the species. Next, the Petition reviews the primary threats to the continued existence of the polar bear, specifically how global warming will likely negatively and severely impact the species' habitat, prey, behavior, reproduction, and ultimately survival. The Petition also explains how existing law and regulations, both domestically and internationally, are inadequate to address the threats from continued global warming and prevent the endangerment and likely extinction of the polar bear. In addition to the discussion of global warming's current and projected impacts on the polar bear, the Petition also contains several appendices which further analyze the status of each of the 20 currently recognized polar bear populations in light of the ESA's policy regarding the protection of distinct population segments, as well as providing further details on several additional threats to the polar bear, including oil and gas development in the Arctic, the accumulation of high levels of persistent organic pollutants such as PCBs in polar bear tissues, and unsustainable hunting practices in some areas outside the United States. In sum, the Petition provides "substantial scientific or commercial information indicating that the petitioned action may be warranted," thereby triggering the statutory requirements for the United States Fish and Wildlife Service ("FWS") to initiate an official review of the status of the polar bear and begin the process of listing the species as Threatened under the ESA. 16 U.S.C. §1533(b)(3)(A).

## Polar Bears: Worldwide Status and Distribution

The polar bear, *Ursus maritimus*, is the apical predator of the Arctic, and the largest of four currently recognized species of bear in the genus *Ursus*. Scientists believe that the polar bear emerged as a distinct species quite recently from a common ancestor with the present-day brown bear (*Ursus arctos*) (FWS 1995; Stirling 1998; Amstrup 2003). The polar bear evolved to exploit the Arctic sea-ice niche, and is completely dependent upon sea ice for survival, where it feeds primarily upon ringed seals (*Phoca hispida*). The polar bear has a circumpolar Arctic distribution, but does not occur in areas where sea ice is not present for a significant portion of the year.

The IUCN/SSC Polar Bear Specialist Group ("PBSG"), the preeminent international scientific body for research and management relating to polar bears, currently recognizes 20 populations, or stocks, of the polar bear species worldwide (Figure 1).

**Figure 1: Distribution of Polar Bear Populations and Sea Ice**
Source: Adapted from Lunn et al. (2002a:23) and ACIA (2004a:25, 30).




**<u>Polar Bear Population Abbreviations</u>**
CS – Chukchi Sea
SB – Southern Beaufort
NB – Northern Beaufort
QE – Queen Elizabeth Islands
VM – Viscount Melville Sound
NW – Norwegian Bay
LS – Lancaster Sound
MC – M'Clintock Channel
GB – Gulf of Boothia
FB – Foxe Basin
WH – Western Hudson Bay
SH – Southern Hudson Bay
KB – Kane Basin
BB – Baffin Bay
DS – Davis Strait
EG – East Greenland
BS – Barents Sea
KS – Kara Sea
LV – Laptev Sea

These 20 populations occur within the jurisdiction of five countries: the US (Alaska), Canada, Denmark (Greenland), Norway, and Russia. Some populations occur entirely within the jurisdiction of one nation, while others are shared between two nations (Table 1).

**Table 1: Jurisdiction of Worldwide Polar Bear Populations**

| **Jurisdiction** | **Population(s)** |
|---|---|
| United States – Russia | Chukchi/Bering Seas |
| United States – Canada | Southern Beaufort Sea |
| Canada | Northern Beaufort Sea |
| | Queen Elizabeth |
| | Viscount Melville Sound |
| | Norwegian Bay |
| | M'Clintock Channel |
| | Gulf of Boothia |
| | Foxe Basin |
| | Western Hudson Bay |
| | Southern Hudson Bay |
| Canada – Denmark (Greenland) | Kane Basin |
| | Baffin Bay |
| | Davis Strait |
| Denmark (Greenland) | East Greenland |
| Norway | Barents Sea |
| Russia | Kara Sea |
| | Laptev Sea |
| International Waters | Arctic Basin |

Scientists have defined the boundaries of the 20 polar bear populations based on analyses of bears in mark-recapture studies, returns of tags from bears killed by hunters, and movements of adult females with satellite radio collars (Stirling and Taylor 1999). In addition, genetic analyses have revealed significant correlations between movement data and genetic data, further reinforcing the appropriateness of these boundaries (Paetkau et al. 1999; Amstrup 2003). Genetics work has also revealed four higher-level population clusters (Paetkau et al. 1999). Further detail on population structure within the polar bear species, and a discussion of distinct population segments eligible for separate listing under the ESA are contained in Appendix A.

The PBSG conducted the most recent comprehensive review of the status of the 20 polar bear populations at its 2001 meeting in Nuuk, Greenland. The PBSG evaluates parameters including population status, abundance, certainty of abundance estimate, level of monitoring of each population, and conservation concerns (Table 2; Lunn et al. 2002a). Worldwide polar bear abundance was most recently estimated at 21,500-25,000 animals (Lunn et al. 2002a; Derocher et al. 2004). Several important points are apparent from the PBSG's synthesis.

First, global warming was listed as a current conservation concern for the majority (11 of 20) of polar bear populations (Table 2 (next page); Lunn et al. 2002a). Current or proposed industrial development was listed as a concern for three of the populations, and pollution was listed as a concern for five (Table 2; Lunn et al. 2002a).

Second, the status of seven of the 20 populations was given as declining or unknown (Table 2; Lunn et al. 2002a).

Third, the certainty of the abundance estimate is rated as “good” for only four of the 20 populations (Table 2; Lunn et al. 2002a). The certainty of abundance estimate is “fair” for an additional eight populations, and “poor” or “unknown” for the remaining eight populations (Table 2; Lunn et al. 2002a). A generally low level of certainty regarding the population estimate weighs in favor of more conservative management strategies.

It is important to note that the PBSG’s status assessments of the various polar bear populations are generally based on the populations’ *current* status. Most polar bear populations, as well as the global species, are not currently endangered. However, the ESA listing criteria, and particularly the definition of “Threatened,” are prospective and forward looking. Evidence of past or current population declines is not necessary before a species is listed as Threatened under the ESA. Therefore, even polar bear populations that are stable or increasing still meet the definition of a Threatened species because the best available science indicates that they are likely to become endangered in the foreseeable future by global warming, disappearance of their sea-ice habitat, and other factors, as detailed below. Since the PBSG’s last review in 2001, evidence has mounted that polar bears are increasingly imperiled, first and foremost by global warming, but also by industrial development, pollution, and overhunting in some areas.

**Table 2: Summary of Polar Bear Population Status**
Source: Adapted from Lunn et al. (2002a:22).

| **Population** | **Abundance Estimate[1]** | **Certainty of Estimate** | **Monitoring of Harvest and other Removals** | **Conservation Concerns[2]** | **Status[3]** |
|---|---|---|---|---|---|
| East Greenland | 2000 | Poor (1997) | Fair | P, W | ? |
| Barents Sea | 2000-5000* | Poor (1982) | Norway-good<br>Russia-poor | P, W | ? |
| Kara Sea | Unknown | Unknown | Poor | P, I | ? |
| Laptev Sea | 800-1200 | Poor (1993) | Poor | P | ? |
| Chukchi Sea | 2000+ | Poor (1997) | US-good<br>Russia-poor | W, I | S? |
| Southern Beaufort Sea | 1800 | Good (2001) | Good | W, I | I |
| Northern Beaufort Sea | 1200 | Good (1987) | Good | W | I |
| Queen Elizabeth | 200 | Poor (1995) | | P | S? |
| Viscount Melville Sound | 230 | Fair (1992) | Good | | S |
| Norwegian Bay | 100 | Fair (1979) | Good | W | S[a] |
| Lancaster Sound | 1700 | Fair (1996) | Good | W | S[a] |

| Population | Abundance Estimate[1] | Certainty of Estimate | Monitoring of Harvest and other Removals | Conservation Concerns[2] | Status[3] |
|---|---|---|---|---|---|
| M'Clintock Channel | 350 | Fair (2001) | Good | W | S? |
| Gulf of Boothia | 900 | Poor (1986) | Good | | S[a] |
| Foxe Basin | 2300 | Good (1996) | Good | W | S[a] |
| Western Hudson Bay | 1200 | Good (1997) | Good | W | S[a] |
| Southern Hudson Bay | 1000 | Fair (1986) | Good | | S |
| Kane Basin | 200 | Fair (1996) | Fair | | S |
| Baffin Bay | 2200 | Fair (1996) | Fair | | D |
| Davis Strait | 1400 | Fair (1996) | Fair | W | D? |
| Arctic Basin | Unknown | Unknown | None | | ? |

[1] Abundance estimates are based on the best available data for each population, which ranges from little information to detailed inventory studies.
[2] I-Industrial development, current or proposed; P-evidence of pollutants in bear tissues; W-evidence of global warming effects on sea ice or populations
[3] D-Decreasing; I-Increasing; S-Stationary; S[a]-Stationary, population managed with a flexible quota system in which any over-harvest in one year results in a fully compensatory reduction to the following year's quota; ?-Indicated trend uncertain
* Surveys conducted in 2004 resulted in a new population estimate of 3,000 animals, at the lower end of the 2001 PBSG estimate (Norwegian Polar Institute 2005).

## Natural History and Biology of Polar Bears

### I. Species Description

The polar bear is the largest of four currently recognized species of bear in the genus *Ursus*, which also includes the brown bear (*U. arctos*), American black bear (*U. americanus*), and Asiatic black bear (*U. thibetanus*). Scientists believe that the polar bear emerged as a distinct species, *Ursus maritimus*, quite recently from a common ancestor with the present-day brown bear (FWS 1995; Stirling 1998; Amstrup 2003). Mitochondrial DNA (mtDNA) sequence analysis reveals that the mtDNA of brown bears in the Alexander Archipelago in southeastern Alaska is more closely related to the mtDNA of polar bears than it is to the mtDNA of other brown bears (Amstrup 2003). Some authors have suggested that Alexander Archipelago brown bears are descendants of the ancestral stock that gave rise to polar bears (Amstrup 2003). This ancestral stock may have survived Pleistocene glaciers in an ice-free area of southeastern Alaska, isolated from brown bears in other Pleistocene refugia (Amstrup 2003). Genetics work also suggests that polar bears branched from the ancestral stock approximately 200,000-250,000 years ago (Amstrup 2003). Polar bears were well developed as a separate species by the beginning of the Eemian interglacial around 125,000 years ago (Stirling 1998). The oldest known polar bear fossil, collected in London, is less than 100,000 years old (Stirling 1998). Analysis of this fossil indicates that this polar bear, like many other Pleistocene era-species, was significantly larger than the modern animal (Stirling 1998; Amstrup 2003).

The polar bear may have evolved during the Saalian glaciation when ice covered the Arctic Ocean and seals became a more readily available year-round and particularly rich source of food (Stirling 1998). During the Saalian glaciation, more of the land surface of Europe was covered with ice than ever before, and the ice fronts would have separated brown bears, dependent on terrestrial resources, from the bears evolving to exploit the new ice and marine niche (Stirling 1998). Over time, the polar bear expanded its range to its current circumpolar distribution (Stirling 1998). Because the polar bear's primary habitat is the surface of the sea ice, rather than terrestrial habitat, it is classified as a marine mammal (Amstrup 2003).

Male polar bears measure from 2.4-3.4 m (8 to 11 feet) and may weigh up to 800 kg (1,700 pounds) (FWS 1998; Stirling 1998). Females measure from 1.8-2.4 m (6-8 feet) and weigh from 181-317 kg (400 to 700 pounds), though very large pregnant females can approach 500 kg (1,100 lbs) (FWS 1998; Stirling 1998).

The polar bear has an elongated neck and a comparatively smaller head than other ursids (Stirling 1998). The polar bear is completely covered with dense white fur, except for the tip of the nose (Amstrup 2003). Beneath their fur, polar bear skin is uniformly black (Amstrup 2003). Adaptations by polar bears to life on sea ice include white fur with water repellent guard hairs and dense underfur, short furred snout, small ears, teeth specialized for a carnivorous rather than an omnivorous diet and hair on the bottom of their feet (FWS 1998; Stirling 1998). Polar bears have enormous oar-like feet (Stirling 1998). Foot shape probably assists propulsion while swimming and also spreads weight as snowshoes would on thin ice, where a bear might otherwise break through the ice (Stirling 1998). Polar bear claws are shorter and more strongly curved than those of brown bears, and larger and heavier than those of black bears, and appear to be well adapted to clambering over blocks of ice and snow and to securely gripping prey animals (Amstrup 2003).

Because the diameter of a male polar bear's neck exceeds the diameter of its head, only female bears will retain radio collars (FWS 1995; Durner et al. 2004). There is still no satisfactory method to attach a radio transmitter to a male polar bear for long-term study (Amstrup 2000).

Polar bears have 42 teeth and a dental formula written 3/3, 1/1, 4/4, and 2/3, where each pair refers to the number of incisors, canines, premolars, and molars respectively, and the first number of each pair indicates the number of teeth on the upper jaw while the second number indicates the number of teeth on the lower jaw (Stirling 1998). Polar bear teeth appear to have evolved significantly from those of their brown bear ancestor (Amstrup 2003). Polar bear teeth are well adapted for grabbing prey and for trimming the fat from the meat and hide, and are no longer suited to grinding grasses or other vegetation (Amstrup 2003).

Other than human hunters, adult polar bears face no natural predators except, in rare circumstances, other adult polar bears (Stirling 1998). The oldest known female polar bear in the wild was 32 years of age and the oldest known male was 28, though few polar bears in the wild live to be older than 20 (Stirling 1990, 1998). The longest lived bear in captivity in a zoo in London lived to be 41 years old. (Stirling 1998).

## II. ADAPTIONS TO THE ARCTIC ENVIRONMENT

Normal body temperature of a resting polar bear is 37°C (98.6° F), quite similar to other mammals (Best 1982; Stirling 1998). A bear's fur, hide, and up to 11 centimeters (4.5 in.) of blubber insulate so well that the bear's body temperature and metabolic rate stay at the normal level even when temperatures drop to -37° C (-34° F) (Stirling 1998). This means that a relatively inactive bear that is not exposed to wind does not have to burn extra energy to stay warm (Stirling 1998). On the other hand, polar bears are very susceptible to overheating (Best 1982; Stirling 1998). Polar bears are so well insulated, in fact, that they give off no heat at all detectable by infrared photography, except for a spot made by their breath (Stirling 1998).

At temperatures ranging from -15° C to -25° C (approximately -4° F to -12° F), polar bear body temperature will stay fairly constant at walking speeds up to 4 km per hour (about 2.5 MPH) (Stirling 1998). After that, however, body temperature begins to climb rapidly, until at about 7 km per hour (4.2 MPH), it is about 39° C (100° F), which is equivalent to a fever in humans (Stirling 1998). In addition, to move at this relatively slow speed, a polar bear must burn 13 times more energy than it would if it were lying down (Stirling 1998). These factors explain why a polar bear's average lumbering gait, which it can maintain for hours, is only about 5.5 km per hour (3.5 MPH) (Stirling 1998). It also explains a report from an Inuk hunter that a hunter with a dog team could run down a polar bear within a few hours on a warm day if the hunter found fresh tracks – the bear would overheat if it had to run for a sustained period (Stirling 1998).

Polar bears radiate heat from their muzzle, nose, ears, footpads, and insides of the thighs, and also, apparently, from blood vessels in the shoulder region which lie only a few millimeters under the skin (Stirling 1998). Polar bears can also cool off by swimming, since water conducts heat about 20 times more efficiently than air (Stirling 1998). For young cubs, however, swimming may be dangerous if it chills their body too much (Stirling 1998).

Bears also thermoregulate by adopting different body positions – they will curl into a ball when exposed to extremely cold, windy weather, but sprawl out to keep cool on warm days (Stirling 1998).

Bears in warm areas like Hudson Bay also move very little in the summer in order to stay cool and conserve energy (Stirling 1998).

Polar bears are extremely inefficient walkers (and runners), expending about twice the average energy use of other mammals when walking (Best 1982; Stirling 1998). The inefficiency of polar bear locomotion likely explains why polar bears are not known to hunt musk oxen or snow geese, potential prey species that co-occur with the polar bear in many areas (Stirling 1998). The energy needed to catch such species would almost certainly exceed the amount of energy a kill would provide (Stirling 1998).[1]

Polar bears appear to have an irregular resting heartbeat (Stirling 1998). One resting female had a heart beat that varied between 53 and 64 beats per minute when she was sleeping undisturbed on a cloudy day at -28° C (-20° F) (Stirling 1998). Another sleeping female had a heartbeat of 80 beats per minute on a sunny day at just above freezing (Stirling 1998). Four males had a sleeping rate of 33 beats per minute at unspecified air temperature (Stirling 1998). When awake but lying down, the average heart rate increased to 46 beats per minute, when sitting up to 58 beats per minute, and when walking between 3 and 6 km per hour (1.5 to 3.5 MPH), to 148 per minute (Stirling 1998).

Polar bears have high digestive efficiency for protein (84%) and fat (97%) for an average energy intake of 92% of what is available in the diet (Stirling 1998; Best 1985). One study has found that an average adult polar bear needs approximately 11 lbs (2 kg) of seal fat per day to survive (Stirling 1998). This nutrition must be obtained primarily during those times of the year when prey is plentiful (Stirling 1998).

Unlike some other species of bears, only pregnant females hibernate through the winter (Stirling 1998; Amstrup 2000). This is not true hibernation as is experienced by some species, but rather a specialized winter dormancy with a slightly depressed heart rate and temperature, during which the bear does not feed or eliminate and lives off its accumulated fat stores (Stirling 1998; Amstrup 2003).

Male and female polar bears can also enter a state termed "walking hibernation" at any time of year when food supplies are scarce, a trait not found in any other bear species (Stirling and Øritsland 1995; Stirling 1998; Amstrup 2003). Walking hibernation means that the bear's metabolism alters to a hibernation-like state, which facilitates significant energy conservation (Stirling and Øritsland 1995; Amstrup 2003), and may make polar bears the most advanced of all mammals in regard to food and water deprivation (Amstrup 2003).

## III. REPRODUCTION

Like other members of the bear family, female polar bears have small litters, reach breeding age late in life, and produce few young in their lifetime (Amstrup 2000). Polar bears have one of the slowest reproductive rates of any mammal (FWS 1995). In most areas, females keep their cubs until they are approximately 2.5 years old, and therefore most females breed only once every three years (Stirling 1998). (For further discussion of variation by population in the reproductive cycle of polar bears, including age of first breeding, see Appendix A). Because the overall ratio of male to female polar bears in most populations is approximately even, this means that on average there are three males for every

[1] Amstrup (2000:149) raises "apparent contradictions between laboratory and field observations of the polar bear's adaption for travel" and suggests that earlier conclusions regarding the efficiency of polar bear locomotion be revisited. Amstrup (2003) also states that additional research is needed on this issue. We are unaware of any more recent data that contradict Best's (1982) treadmill studies.

available breeding female, producing intense competition (Stirling 1998). Polar bears are one of the most sexually dimorphic of all mammals, though in other sexually dimorphic species there are generally fewer males than females (Stirling 1998).

Polar bears mate on the sea ice in either April or May (Stirling 1998). Fighting will generally occur between multiple males until one asserts dominance and is able to lead the female to areas away from prime feeding habitat where they remain together for up to a week or more (Stirling 1998). Female polar bears undergo induced ovulation, and it may take several days of mating in order to successfully stimulate ovulation and to ensure fertilization (Stirling 1998).

After mating, a female must accumulate sufficient fat reserves to live and to support her cubs from the time she enters the maternity den between late October and mid-November until the time the family emerges in the spring and the female once again begins to feed (Stirling 1998). The length of time a female must fast varies by region (Stirling 1998), as detailed in Appendix A.

Pregnant female polar bears den in a variety of substrates, with some populations denning entirely on sea ice, some entirely on land, and some using a mixture of both (Appendix A). Dense, hardened snow from the previous year appears to be preferred in most areas, while in some areas like Hudson Bay bears dig dens directly into the permafrost (frozen earth) (Stirling 1998). Dens in both snow and earth may be re-used by different bears over the years, sometimes for several centuries (Stirling 1998; Derocher et al. 2004).

Bears everywhere construct maternity dens that are architecturally similar, usually consisting of a single chamber at the end of a long, narrow entrance (Stirling 1998). Sometimes two and three chamber dens are excavated, and cubs will also sometimes excavate small alcoves (Stirling 1998).

Scott and Stirling (2002) analyzed terrestrial den use in the Western Hudson Bay population by examining growth rings in black spruce trees that indicated damage caused by polar bear denning activities. In Western Hudson Bay, most pregnant females utilize dens dug into the permafrost along river banks and lakeshores, and may extend the dens once drifting snow accumulates later in the winter (Scott and Stirling 2002). This ingenious study revealed some dens dated as early as 1795, indicated that 12 of 31 den sites were older than 100 years, and demonstrated a high rate of re-use of dens (Scott and Stirling 2002). The results indicate a high degree of fidelity to the studied denning area, where 90% of the females in the population are estimated to den (Scott and Stirling 2002). While historical denning activity in areas where dens are dug exclusively in snow is impossible to reconstruct because the dens melt, the results suggest that bears further north may behave similarly (Scott and Stirling 2002). Overall, the results demonstrate that protecting core maternity denning areas is of critical importance to the long-term conservation of the polar bear (Scott and Stirling 2002).

In the Beaufort Sea, a significant percentage of female bears den on the drifting pack ice. Bears that den on drifting pack ice may be carried up to 1000 km between the time they enter and emerge from their dens, reducing the predictability of resources upon emergence of the female and her new cubs from their den (Amstrup 2000; Derocher et al. 2004). Additionally, natural phenomena such as rapidly moving and shifting ice can disrupt polar bear dens (Amstrup 2000). Two female polar bears were observed with tiny cubs in their mouths, “probably in desperate attempts to relocate to a new den site” when their dens were swept past Point Barrow and southwest into the Chukchi Sea due to unusually unstable ice (Amstrup 2003:596).

While land dens are safe from this type of natural disturbance, they are more vulnerable to a variety of human-induced disruptions. Development-related activities have potential to disrupt polar bear denning. Some denning habitat has already been exposed to these activities (Amstrup 2000). Areas of concentrated polar bear denning include the Arctic National Wildlife Refuge in the United States, particularly the portion of the coastal plain know as the "1002 Area," the islands of Kong Karls Land, Nordaustlandet, Edgeøya, and Barentstøya in the Svalbard Archipelago north of Norway (Larsen 1985), Franz Josef Land, Novaya Zemlya, and Wrangel Island in Russia, and the west coast of Hudson Bay in Canada (Amstrup 2002).

Polar bear cubs are born between late November and early January, though again, the timing varies by region and population (Stirling 1998; Amstrup 2000). Polar bear young are among the most undeveloped of placental mammals (Amstrup 2000). Cubs are born with their eyes closed, weighing approximately less than a kilogram (1-1.5 lbs.) (Stirling 1998; Amstrup 2000). Because of their vulnerability at birth, cubs must remain in the maternity den for protection from the rigors of the Arctic winter (Amstrup 2000), where researchers believe the ambient temperature approaches 0° C (Blix and Lentfer 1979). Female polar bears provide additional warmth insulation for their altricial cubs by curling their bodies about the cub (Blix and Lentfer 1979). Female polar bears have four functional nipples to nurse their young (Stirling 1998). Cubs nurse inside the den until sometime between late February and the middle of April, depending on the latitude (Stirling 1998). Females will break out of their dens sooner in the more southerly regions that warm earlier in the year (Stirling 1998).

By the time they emerge from the dens, cubs are approximately three months old and weigh between 10 to 15 kg (25 to 30 lbs) (Stirling 1998; Amstrup 2000). Following den emergence, family groups generally remain in the vicinity of the den for up to several weeks while the cubs play and nurse but continue to spend the majority of their time in the den (Stirling 1998). This period is likely important for acclimatization of the cubs from the relative warmth of the den to exposure to the Arctic environment (Stirling 1998). At the end of this acclimatization period, the mother and cubs begin their trek to the sea ice to feed on seals (Stirling 1998).

Females nurse their young for up to two and a half years on milk that, in one study, contained an average mean fat content of 33.1 percent, higher than that of any other species of bear and comparable to that of marine mammals (Stirling 1998). The age at which most mothers wean their cubs also varies by region from approximately 1.5 years in the Western Hudson Bay population to up to 3.5 years in the Viscount Melville Sound population, though in most areas cubs are weaned at approximately 2.5 years of age, resulting in a three year reproductive cycle (Stirling 1998).

In most areas, females breed for the first time at four years of age (Stirling 1998), but in both the Alaskan and Canadian Beaufort sea area, females to do not breed for the first time until they are six years old (Stirling 1998; Amstrup 2000). Male polar bears generally reach sexual maturity at six years of age, but do not mate until they have become strong and skillful enough to emerge as the dominant bear in competition for females (Stirling 1998).

About two thirds of all polar bear litters consist of twins, most of which are fraternal, rather than identical (Stirling 1998). Single cubs account for an additional 20-30% of litters, and triplets for the remaining small percentage, with triplets more common in the lower latitudes (Stirling 1998). Usually, triplet litters consist of two relatively equally sized cubs and a much smaller cub that is unlikely to survive, termed the "underbear" by Stirling (1998). Existing data on litter size and cub survival are sparse due to the extreme difficulty both of collecting information on the number of cubs emerging from dens across the Arctic as well as in tracking cub survival (Stirling 1998). Stirling (1998) calculated average litter sizes based on existing data ranging from 2.0 in Hudson Bay to 1.56 in the Central Canadian Arctic. Due to cub mortality, yearling litter sizes are smaller, ranging from 1.68 on the Manitoba coast of Hudson Bay to 1.23 in Svalbard (Stirling 1998). Stirling (1998) estimates first year cub mortality at 20-40%, varying by population.

**Figure 2: Mother Polar Bear Nursing Ten Month Old Cubs at Western Hudson Bay, Canada**

Polar Treasure ©Thomas D. Mangelsen/Imagesofnaturestock.com

A complete reproductive cycle is energetically expensive for female polar bears, and they will defer reproduction in favor of survival when food availability is low (Amstrup 2003). The reproductive cycle of a female polar bear lends itself to early termination when a bear is energetically stressed, because the early stages of pregnancy are far less energy intensive than nursing and raising a cub (Amstrup 2003). Stirling (1998) reports seven documented instances of females so emaciated that they killed and ate one or both of their cubs in order to survive themselves and breed again.

The most difficult time of a polar bear's life is from the time it is weaned to when it becomes a successful adult hunter at five or six years of age (Stirling 1998). Subadults are less experienced at hunting and make fewer kills than adults, and, in addition, often lose kills they do make to larger bears (Stirling 1998). Scientists have captured very few fat subadults, and therefore believe that their greatest mortality factor is starvation (Stirling 1998).

Because polar bears exist in relatively small populations and have low reproductive rates, populations may be detrimentally impacted by even small reductions in the number of individuals (Amstrup 2000). The very low reproductive rate means that there must be a high rate of survival to maintain population levels (Amstrup 2003). Even without human impacts on survival, the maximum rate of increase for polar bear populations is small (Amstrup 2000).

## IV. DIET

Polar bears are the apical predators of the Arctic marine ecosystem (Amstrup 2003) and are specialized predators of phocid seals in ice-covered waters (Derocher et al. 2004). Their primary prey consists of ringed seals (*Phoca hispida*) and bearded seals (*Erignathus barbatus*) (Derocher et al. 2004). Other species such as harp seals (*P. groenlandica*), beluga whales (*Delphinapterus leucas*), narwhal (*Monodon monocerus*), and walrus (*Odobenus rosmarus*) are also taken, though they appear to be of secondary importance (Derocher et al. 2004).

The Arctic food web is simple and fragile (FWS 1995). Eponic algae are eaten by zooplankton, which are eaten by fish, including primarily Arctic cod (FWS 1995). Arctic cod are eaten by seals, and seals by polar bears (FWS 1995). Baleen whales eat zooplankton, beluga whales eat fish, and humans eat whales, fish, seals, and polar bears (FWS 1995). The near-shore benthic community is limited due to ice scouring. The offshore benthic community consists of mollusk and benthic amphipods that support walrus and, in some areas, grey whales, respectively (FWS 1995).

Although polar bears are capable of catching ringed seals of all age classes, ringed seal young-of-the year comprise the bulk of their diet in the Canadian Arctic (Stirling and Archibald 1977; Stirling and Øritsland 1995; Stirling and Lunn 1997), and likely in other areas as well, though one unpublished study in Alaska found that 56% of the kills were adult seals older than two years, 39% were juveniles, and 5% were pups (FWS 1995).

Ringed seals are most abundant and easily caught in the spring, when they give birth to their pups (Stirling 1998). Females give birth in subnivean lairs (on top of the ice but hidden under snowdrifts) to pups which are approximately 10 lbs. (4 to 5 kg) at birth but 50 to 60 lbs. (25 to 30 kg) by the time they are weaned (Stirling 1998). Because newly weaned pups are 45 to 75 percent fat, and have not yet learned to avoid predators, they provide an energy intensive and abundant source of food for polar bears (Stirling 1998). Nursing females are also fat and provide even more energy than their pups (Stirling 1998). By the time young seals have dispersed into open water around the time of break-up, polar bears have obtained their highest annual weight (Stirling 1998).

Polar bears will also feed on whale and seal carcasses, including those that wash up on the shore naturally and those left by human hunters (FWS 1995). A floating or beached whale can attract more than 30 polar bears (FWS 1995).

Occasionally bears eat some vegetation on land, but it is unlikely that it contributes significantly to their overall energy requirements (Stirling 1998; Derocher et al. 2004). There are reports of polar bear predation, attempted predation, or possible predation on various terrestrial species including caribou, reindeer, musk ox, and willow ptarmigan (Brook and Richards 2002). Natives on St. Lawrence Island have observed polar bears eating crabs, clams, ground squirrels, long-tailed ducks, and kelp (FWS 1995). One polar bear was observed diving for kelp (Stirling 1998). Bears are sometimes observed trying to capture sea birds and ducks by diving underneath them and biting them from below (Stirling 1998). However, research indicates that such species form only a minor component of polar bear diet (Brook and Richards 2002). The significance of terrestrial foraging to polar bears is not well understood

(Amstrup 2003), but polar bears experiencing reduced seal availability are unlikely to be able to compensate by switching to terrestrial food sources (Derocher et al. 2004).

## V. HUNTING AND FEEDING

Polar bears hunt seal with two primary methods, "stalking," and "still hunting," each of which itself has several variations (Stirling 1998). Stalking occurs when a polar bear spots a seal on the ice from a distance and then approaches slowly and stealthily to within about 15 to 30 meters, sometimes moving in a semi-crouch as it gets closer (Stirling 1998). Ringed seals are alert on the ice and often raise their heads to look for predators (Stirling 1998). Once close enough, the polar bear will make a final charge and attempt to catch the seal before it can disappear back into its hole in the ice (Stirling 1998). Ringed seals usually haul-out alone at a breathing hole, likely because the presence of more than one seal could cause a delay that would give the bear extra time to catch its quarry (Stirling 1998), a scenario that has in fact been observed in the wild (Mangelsen and Bruemmer 1997). After catching a seal in this manner, the polar bear will bite its head many times before dragging the carcass away from the breathing hole to consume it (Stirling 1998).

Some bears specialize in what Stirling (1998) has termed the "aquatic stalk." In one variant, the bear dives into the water and swims towards the target seal in the distance, stealthily surfacing at unoccupied seal breathing holes to breathe itself (Stirling 1998). Stirling (1998) has observed bear submersion times in this manner of up to 72 seconds (Stirling 1998). The bear then swims to the hole at which the target seal is hauled out, surfaces at the hole and at the same time attempts to grab the seal (Stirling 1998). Stirling (1998) reports that this hunting method is unsuccessful more often than not. A variant on the aquatic stalk is the use of water-filled channels that form on top of the sea ice in the summer, in which a bear can submerge almost entirely while it moves towards its prey (Stirling 1998). Bears appear to memorize their route beforehand in these aquatic stalks, and appear capable of following a pre-set plan for the hunt (Stirling 1998). While bears seldom catch seals in open water, there is at least one reported instance of a bear capturing a seal by remaining still in the water until a seal surfaced less than half a meter from it, at which time it successfully grabbed the seal, though this is likely to be a localized behavior practiced by only a small number of bears (Stirling 1998).

Still-hunting is the second primary hunting method, accounting for 80% of hunting in the summer, and an even higher percentage in winter, since few seals haul-out on the ice (Stirling 1998). Bears locate breathing holes used by seals, probably by their scent, and wait motionless on the ice until a seal surfaces again, at which time it will pounce and snatch the seal (Stirling 1998). Usually the bear will lie down on the ice with its chin close to the edge of the hole, but sometimes a bear will sit or stand (Stirling 1998). Most still-hunting lasts for under an hour, but can go on for much longer (Stirling 1998).

Winter brings its own hunting challenges and opportunities. As winter progresses, remaining cracks in the ice where seals surface to breathe begin to freeze, and the seals must maintain them (Stirling 1998). When the ice is young and thin, seals do this simply by pushing through the ice with their heads, and polar bears can access the seals at such sites (Stirling 1998). As winter progresses, however, the remaining cracks freeze and drifting snow accumulates over the cracks and pressure ridges, removing all visible signs of the remaining holes where the seals now concentrate (Stirling 1998). Later in the winter, as the drifts over the breathing holes deepen, some seals excavate small haul-out lairs above their breathing holes (Stirling 1998). These caves are then used by pregnant females in the spring to birth and nurse their pups (Stirling 1998).

Polar bear eyesight is probably similar to that of a human being, but its sense of smell is many times more powerful (Stirling 1998). Polar bears can locate subnivean (under the snow) seal lairs by smell (Stirling 1998). The bear will then wait beside the lair until it smells or hears a seal inside, at which time it attempts to crash through the top of the lair and grab the seal (Stirling 1998). If the bear cannot break through the hard snow surface on its first try, the seal will almost certainly be gone before it can do so (Stirling 1998). A trained Labrador retriever can detect a seal breathing hole under 1 meter of snow from over a kilometer away, and a polar bear's sense of smell is likely at least as good as the retriever's (Stirling 1998).

Cubs learn to hunt by repeatedly watching their mothers hunt (Stirling 1998). Cubs of the year do very little hunting on their own, while two year old cubs still follow their mothers but may range up to several kilometers from her and begin to independently select hunting sites (Stirling 1998). Ringed seal pups hunted in the spring are a critical component of the polar bear's annual food intake, and unwary young seals are particularly important for cubs learning to hunt (Stirling 1998).

There are reports of polar bear predation on other species such as belugas whales, narwhals, and walrus (Stirling 1998). During the winter, belugas and narwhals sometimes become entrapped at a breathing hole when all the surrounding ice freezes, a situation termed a "savsatt" by the Inuit people (Stirling 1998). Many whales can be crowded into a very small area by their need to breathe, and this can present a unique hunting opportunity for polar bears (Stirling 1998). Biologists have reported one incident where up to 15 bears killed 40 or more belugas at a savsatt just south of the Bering Straight (Stirling 1998). There are also reports of polar bear predation on belugas at Cunningham Inlet on the north coast of Somerset Island and at Gascoyne Inlet on the southwest corner of Devon Island (Stirling 1998), and at Elwin Bay on the east coast of Somerset Island (Mangelsen and Bruemmer 1997).

Polar bear kills of walrus have also been reported, though walrus, unlike seals, are able to fight back and possibly kill polar bears as well (Stirling 1998). Stirling (1998) reports one group of walrus that surfaced en masse and charged a female polar bear that had approached walruses hauled out on the ice, successfully scaring the bear away from the area (Stirling 1998).

Polar bears are not known to feed on fish such as Arctic char, though there is one report from the July 1778 of thirty-two white bears feeding on salmon along with three black bears in the Eagle River to the west of Cartwright on the Labrador Coast (Stirling 1998).

Immediately after capturing a seal, a polar bear will drag it from the edge of the water and begin feeding voraciously (Stirling 1998). Consuming a large part of the seal quickly is important because adult polar bears will attempt to take another's kill (Stirling 1998). Polar bears strongly prefer the seal's fat, and will often eat only the fat while leaving the meat and skin behind (Stirling 1998).

Polar bears to not cache their kills like brown bears do (Stirling 1998). If uninterrupted, a bear will likely feed for an hour or more, though often one or more other bears will approach (Stirling 1998). Two males of approximately equal size will likely feed together and not fight (Stirling 1998). A female and cubs approached by a male will often desert the kill, though if the family group has not fed for a long time the female may defend the kill (Stirling 1998). Carcasses left by adult bears are an important food source for cubs, as well as for Arctic foxes, which follow polar bears out onto the ice for this purpose (Mangelsen and Bruemmer 1997; Stirling 1998).

Polar bears are surplus hunters. Scientists have observed polar bears killing ringed seal pups without consuming them (Stirling 1998). Amstrup (2003:592) reports as follows:

> I once observed a young male polar bear still-hunting at a breathing hole on new autumn ice. There was a partially consumed seal nearby, and between that feeding site and where he was still-hunting were three freshly killed ringed seals stacked like cordwood. When my helicopter approached the bear to capture him, he abandoned his still-hunting site, ran to the pile of dead seals, and covered them with his body as if to protect his stash. This bear apparently had eaten his fill from the first seal but was continuing to hunt, catch, and stack seals despite a low probability that he would consume much of them.

Washing is an important and integral part of polar bear feeding behavior (Stirling 1998). Generally, after an initial feeding period of 20 to 30 minutes, a bear will go to a pool of water, rinse, and lick its paws and muzzle (Stirling 1998). In the winter when water is not available, a bear will rub its head in the snow and roll on its back to clean itself (Stirling 1998). This washing behavior is so important that bears at the dump at Churchill, Manitoba would periodically walk an entire kilometer to Hudson Bay to wash (Stirling 1998).

Polar bears do not discriminate well between food and non-food items, and will eat plastic, Styrofoam, and toxic trash such as batteries (FWS 1995). Polar bears will scavenge at human dumps and refuse sites if these are available to them. Due to this characteristic polar bears are at risk from toxic substances introduced into their habitat.

## VI. Swimming

Polar bears are excellent swimmers and will swim while actively hunting, for movement between hunting areas, and for movement between sea ice and terrestrial habitat. Polar bears have also been observed swimming for no apparent reason (Stirling 1998). Polar bears are capable of swimming long distances. Bears in the eastern Barrow Strait have been tracked swimming for approximately 100 km (Stirling 1990).

Polar bears are buoyant due to their high body fat and swim in a dog-paddle manner with their large oar-like feet, occasionally using their back legs as rudders (Stirling 1998).

Despite the polar bear's excellent swimming ability, scientists believe that swimming uses more energy than walking, and that this explains, at least in part, why bears will abandon the melting sea ice for land in the summer once the ice concentration drops below 50% (Derocher et al. 2004).

## VII. Sleeping and Resting

During the summer, polar bears sleep approximately 25% of the time (Stirling 1998). Bears generally lie with their backs or sides to the wind, and often dig pits in the snow in which to sleep, which may then be covered with blowing snow (Stirling 1998). In snow-free areas such as Hudson Bay, bears sleep in pits dug into the sand or along gravel ridges on the beach (Stirling 1998). Females with cubs will often climb several hundred meters up snow slopes and dig a pit big enough for the family group, probably to reduce the risk of a surprise encounter with an adult male (Stirling 1998). Polar bears can sleep in any position, and always appear to like a sleep several hours after feeding (Stirling 1998).

Bears in many areas use temporary dens for sheltering and energy conservation (Amstrup 2003). Bears in the Western Hudson Bay population use dens during the summer for sheltering from heat and insects, while bears at higher latitudes use dens during the winter for shelter from extreme weather (Amstrup 2003; see also Appendix A).

## VIII. HABITAT REQUIREMENTS

Polar bears are distributed throughout the ice-covered waters of the circumpolar Arctic (Stirling 1998), where they are totally reliant on the sea ice as their primary habitat (PBSG 2005). Polar bears evolved to exploit the sea-ice niche, are adapted to survival on this habitat (Stirling and Derocher 1993), and do not occur in areas where there is not sea ice for substantial portions of the year. Polar bears depend on sea ice for a number of purposes, including as a platform from which to hunt and feed upon seals, as a habitat on which to seek mates and breed, as a vehicle from which to access terrestrial maternity denning areas, and sometimes for maternity denning habitat itself, and as a substrate on which to make long-distance movements (Stirling and Derocher 1993). Because polar bears catch very few seals in open water, sea ice is the essential platform from which they hunt (FWS 1995; Tynan and DeMaster 1997; Stirling 1998; Derocher et al. 2004).

Polar bear distribution is not uniform throughout the Arctic, but depends upon the nature and spatial and temporal extent of sea ice, availability of prey, and the requirements of the polar bear's reproductive status (Durner et al. 2004). Stirling et al. (1993) conducted surveys of a 74,332 $km^2$ area in the eastern Beaufort Sea and Amundsen Gulf in the western Canadian Arctic between mid-March and the end of May, 1971 through 1979. These researchers defined seven types of sea-ice habitat and recorded sightings of polar bears and their tracks in each habitat type in order to determine polar bear habitat preferences. The seven types of sea ice described by Stirling et al. (1993) are as follows:

(1) Stable fast ice with drifts: Generally flat areas of annual ice, interspersed with pressure ridges that have moved little since consolidation at freeze-up. The pressure ridges are stable and drifted with snow, suitable for ringed seal haul-out and birth lairs. This habitat is most prevalent in the mouths of bays and near coastlines or offshore islands because that is where the annual ice is most stable.

(2) Stable fast ice without drifts: Similar to the habitat described above, but lacks the well-developed drifts along the pressure ridges that ringed seals require to protect birth lairs and breathing holes from predation.

(3) Floe edge: the area along the edge of the landfast ice where leads are greater than 1 km wide. There are usually small open or refrozen leads parallel to the floe edge or emanating from it. This includes areas of less than 7/8 ice cover, adjacent to the landfast ice, where large floes are intermixed with smaller leads and patches of open water. Bearded seals of all age and sex classes and non-breeding ringed seals are generally abundant in this habitat. The amount of snow along the pressure ridges is variable.

(4) Moving ice: the ice cover is 7/8 or more but the floes shift constantly because of wind and ocean currents, creating a continuous pattern of intermittent narrow cracks or patches of open water that then refreeze. There is usually little drifted snow except along pressure ridges on larger floes that have not been broken up by movement of the ice. Snow drifts in these areas are generally not stable enough to be suitable for ringed seal birth lair habitat, though bearded seals of all age and sex classes and non-breeding ringed seals are generally abundant in this habitat.

(5) Continuous heavy pressure: Created by strong pressure on the ice so that it rafts, becoming compressed, and forms extensive areas of very rough ice that then refreeze and remain fairly stable. This habitat is generally unsuitable for seals.
(6) Coastal pressure ridges: Cracks in the annual ice, which usually develop into low pressure ridges that accumulate drifted snow, form parallel to the coastline because of the daily rise and fall of the tide. The pressure ridges are stable and drifted with snow, suitable for ringed seal haul-out and birth lairs.
(7) Fiords and bays: In large bays such as Prince Albert Sound, the annual ice freezes early and remains fairly smooth through the winter because of being locked in place by the land. Long, low, and snow-drifted pressure ridges, and cracks that refreeze and remain flat, usually recur in the same places each year because of similar annual patterns of wind and currents, and are used by ringed seals for birth lairs and breathing holes. This habitat is not widespread in other areas of the Arctic outside of the study area.

Polar bears are also not evenly distributed over their sea-ice habitat, but are concentrated in the three most important types of sea ice which are (1) the ice floe edge; (2) stable fast ice with drifts; and (3) areas of moving ice (Stirling 1990; 1993; Table 3).

**Table 3: Number of Bears and Tracks Sighted by Habitat Type in the Western Canadian Arctic, 1971-1979**
Source: Adapted from Stirling et al. (1993:20).

| | **Fast ice with drifts** | **Fast ice without drifts** | **Floe edge** | **Moving ice** | **Heavy pressure** | **Coastal pressure ridges** | **Fiords/bays** | **Total** |
|---|---|---|---|---|---|---|---|---|
| **Bears[1]** | 98 | 2 | 265 | 249 | 10 | 3 | - | 627 |
| **Total Bears** | 157 | 4 | 296 | 314 | 11 | 9 | - | 791 |
| **Bears/100km** | 0.66 | 0.09 | 2.17 | 1.11 | .72 | .82 | - | |
| **Tracks/100km** | 4.24 | 2.35 | 11.97 | 12.40 | 7.42 | 6.37 | 1.05 | |

[1] in this column, family groups are counted as one sighting.

The strong preference of polar bears for the floe edge, fast ice with drifts, and moving ice with greater than 7/8 ice cover is almost certainly because these areas have the highest seal concentrations and the seals are also accessible to polar bears for hunting. Seals are abundant in these areas, and they can be taken at their breathing holes and birth lairs by polar bears (Stirling et al. 1993; 1998).

Stirling et al. (1993) also note that the rate at which polar bears and tracks were sighted in heavy pressure ice was unexpectedly high, as it appears to be poor habitat because it is difficult for polar bears to walk through, seals that may be present are relatively inaccessible, and there were no signs of hunting or seal kills. The authors conclude that the high rate of sightings are likely due to the proximity of high-pressure ice to the preferred habitat types, and not to the ecological value of high-pressure ice itself (Stirling et al. 1993).

Polynas are areas of open water surrounded by ice that are also extremely important to polar bears (Stirling 1997). While polynas are not themselves a sea-ice habitat type, they occur adjacent to the sea-ice habitat preferred by polar bears. Polynas vary in size and can be caused by wind, tidal fluctuations, currents, upwellings, or a combination of these factors (Stirling 1997). Polynas are areas of increased productivity at all trophic levels in Arctic waters, particularly where they occur over continental shelves, and therefore the sites of marine mammal and bird concentrations (Stirling 1997).

Additional reasons why animals concentrate at polynas may include calmer water which facilitates resting and hunting, a temporary barrier to migration, a navigational aid to migrating species, a place where marine mammals can surface to breathe and seabirds can feed, and habitat in which some species can escape from predators (Stirling 1997). The increased biological productivity, however, is likely the key factor in the ecological significance of polynas (Stirling 1997).

Polar bears concentrate in areas where a new lead in the ice has been opened up by strong winds or other factors (Stirling 1998), and are extremely adept at finding and using these dynamic and productive lead systems (FWS 1995). Wherever this habitat occurs, it is highly likely that polar bears will find it and use it (FWS 1995).

In the Canadian Arctic, polar bears concentrate each year at the North Water polynya in Smith Sound and northwestern Baffin Bay, which contains open water all year, and at smaller permanent polynyas at Cardigan Strait-Hell Gate, Penny Strait-Queens Channel, and in the eastern entrance to Fury and Hecla Strait (Stirling 1980). Polar bears also concentrate at shore leads where seals maintain their breathing holes (Stirling 1980).

Polar bears use both marine and terrestrial habitats for feeding, denning, breeding, and seasonal movements (FWS 1995). Polar bears must move throughout the year to adjust to the changing distribution of sea ice and seals (Stirling 1998; FWS 1995). In some areas, like Hudson Bay and James Bay, bears remain on land when the sea ice retreats in the spring, where they must fast for several months (up to eight months for pregnant females) before freeze-up again in the fall (Stirling 1998; Derocher et al. 2004). Some of the higher latitude populations, such as those in the Chukchi and Beaufort seas, spend each summer on the multiyear ice of the polar basin (Derocher et al. 2004). In intermediate areas such as the Canadian Arctic archipelago or Svalbard and Franz Josef Land archipelagos, bears stay with the ice most of the time, but in some years they may spend up to a few months on land (Stirling 1998). Most populations use terrestrial habitat partially or exclusively for maternity denning, and therefore females must adjust their movements so that they have access to land at the appropriate time (Stirling 1998; Derocher et al. 2004).

Telemetry data from radio-collared female polar bears confirm that individuals occupy home ranges (or "multiannual activity areas") which they seldom leave (Amstrup 2003:592). The size of a polar bear's home range is determined, at least in part, by the annual pattern of freeze-up and break-up of the sea ice, and therefore the distance a bear must travel to obtain access to prey (Stirling 1998). A bear that has constant access to ice, leads, and seals may have a very small home range, while bears in areas such as the Barents, Greenland, Chukchi, or Bering seas may have to move many hundreds of kilometers each year to remain in contact with sea ice from which they can hunt (Stirling 1998; Amstrup 2003). Appendix A describes the differing movement patterns among polar bear populations. Amstrup (2003:593) reports that telemetry data have confirmed polar bears' close ties to the ice, and that "[s]easonal movement patterns of polar bears serve to emphasize the role of sea-ice in their life cycle."

Polar bears are generally far-ranging animals, and female polar bears denning on pack ice are passively and blindly carried further by drifting sea ice than any other vertebrate (Amstrup 2003). Polar bears have strong navigational ability and are able to return to previously used areas after both active and passive transport of long distances (Amstrup 2003). Scientists do not yet understand how polar bears accomplish this feat (Amstrup 2003).

Durner et al. (2004) have developed models to predict polar bear distribution based on a quantitative analysis of the movements of female polar bears over a multi-year period in the Beaufort Sea. In the future, these models may be used to make short-term predictions of polar bear distribution and abundance and therefore aid scientists and managers in predicting and responding to initial impacts from threats such as oil development and global warming (Durner et al. 2004).

## The Polar Bear Meets the Definition of a Threatened Species under the Endangered Species Act

### I. CRITERIA FOR LISTING SPECIES AS ENDANGERED OR THREATENED UNDER THE ENDANGERED SPECIES ACT

Under the ESA, 16 U.S.C. § 1533(a)(1), FWS is required to list a species for protection if it is in danger of extinction or threatened by possible extinction in all or a significant portion of its range.[2] In making such a determination, FWS must analyze the species' status in light of five statutory listing factors:

(A) the present or threatened destruction, modification, or curtailment of its habitat or range;
(B) overutilization for commercial, recreational, scientific, or educational purposes;
(C) disease or predation;
(D) the inadequacy of existing regulatory mechanisms;
(E) other natural or manmade factors affecting its continued existence.

16 U.S.C. § 1533(a)(1)(A)-(E); 50 C.F.R. § 424.11(c)(1) - (5).

Global warming is the primary threat to the continued survival of the polar bear, and primarily implicates ESA listing criteria (A) through the present and threatened destruction, modification, and curtailment of polar bears' habitat and range. Global warming implicates other factors as well, including factor (D), the inadequacy of existing regulatory mechanisms to slow, halt, or reverse global warming.

In addition to the overarching threat of global warming, the polar bear faces many other threats including oil and gas exploration and development, high body burdens of persistent contaminants such as PCBs, and unsustainable harvest levels in some areas. Global warming will interact in a synergistic and/or cumulative fashion with many of these additional threats to the polar bear. Overall, each of the five listing factors is implicated by one or more threats to the polar bear.

A species is "endangered" if it is "in danger of extinction throughout all or a significant portion of its range" due to one or more of the five listing factors. 16 U.S.C. § 1531(6). A species is "threatened" if it is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." 16 U.S.C. § 1531(20). While the ESA does not define the foreseeable future, the FWS must use a definition that is reasonable, that ensures protection of the polar bear, and that gives the benefit of the doubt regarding any scientific uncertainty to the polar bear.

The IUCN threatened species classification system provides one useful analogy for determining the proper timeframe for consideration as the foreseeable future. Under the IUCN system, extant species within the overall threatened category are further categorized as "critically endangered," "endangered," and "vulnerable" (IUCN 2001). A reviewer categorizing a species must consider each

[2] In making this determination, the FWS must rely "solely on the best scientific and commercial data available." 16 U.S.C. § 1533(b)(1)(A). Regrettably, political considerations are routinely inserted by political appointees at the Department of Interior into determinations that should be entirely science-based (Union of Concerned Scientists 2005a;b;c). Petitioner urges the FWS to consider only the best scientific information available in its determination on this Petition.

category in turn and place the species in the highest category of threat for which it meets any one of the IUCN's criteria (some criteria may never be applicable to some species, no matter how likely they are to become extinct)(IUCN 2001). For example, a species must be classified as "vulnerable" if it meets the following criteria: "Quantitative analysis showing the probability of extinction in the wild is at least 10% within 100 years" (IUCN 2001). The "foreseeable future" for the purposes of IUCN classification therefore cannot be less than 100 years. Another example of the classification system is that a species must be listed as "endangered" if a quantitative analysis shows "the probability of extinction in the wild is at least 20% within 20 years or five generations[3], whichever is the longer (up to a maximum of 100 years)" (IUCN 2001). Under the IUCN system the overall timeframe for consideration cannot be less than 100 years.

Based on considerations such as Congress's mandate to protect species from extinction and the IUCN analogy, the FWS must consider threats to the polar bear on a timeframe of <u>at least 100 years</u>. The time period considered must also be long enough so that actions can be taken to ameliorate the threats and prevent extinction. Addressing global warming, the primary threat to the polar bear, will be a long-term process for a number of reasons, including the long lag time between anthropogenic greenhouse gas emissions and climate changes. Because every country produces greenhouse gas emissions (though the United States is by far the largest emitter), reducing emissions has been an extremely difficult challenge, from political, technological, and practical perspectives. The FWS may not adopt a time frame for the foreseeable future that would make it impossible for actions to address the threat to take effect quickly enough to prevent extinction. For all these reasons, Petitioners suggest consideration of <u>200 years</u> as the "foreseeable future" for analyzing the threats to the continued survival of the polar bear.

As detailed below, neither global warming nor any of the other threats to the polar bear are speculative or too far in the future to understand or address. Tragically, these new and modern threats are already here, and the impacts are already manifesting in polar bear populations. Urgent action, including listing under the ESA and dramatic cuts in emissions levels, is needed now to ensure that the polar bear does not become extinct in the foreseeable future. As described below, the polar bear meets the definition of a Threatened species under the ESA.

## II. GLOBAL WARMING THREATENS THE CONTINUED EXISTENCE OF POLAR BEARS

The disappearance and degradation of the polar bear's sea-ice habitat due to global warming is the primary threat to its continued existence. The prognosis for the polar bear is grim. The earth's climate has already warmed perceptibly, and a number of feedbacks lead to much higher ongoing and future levels of warming in the Arctic as compared to the global average. Even slight increases in average Arctic temperature will likely cause dramatic changes in the sea ice on which polar bears depend (Durner et al. 2004). Observed changes to date in sea ice include reduced sea-ice extent, particularly in the summer, and progressively earlier break-up dates, especially in southerly portions of the species' range, such as Hudson Bay. Global warming is projected to continue and to accelerate, with the best available science indicating the near complete disappearance of summer sea ice by the end of this century, <u>even under optimistic assumptions of reductions in greenhouse gas emissions</u>. Without sea

[3] The IUCN defines generation length as the average age of parents of the current cohort (i.e. newborn individuals in the population) (IUCN 2001). Generation length therefore reflects the turnover rate of breeding individuals in a population (IUCN 2001). Generation length is greater than the age at first breeding and less than the age of the oldest breeding individual, except in taxa that breed only once (IUCN 2001).

ice, the polar bear is very likely to become extinct, and without question would qualify as an endangered species. Unless greenhouse gas emissions are cut dramatically in the immediate future, the disappearance of sea ice is essentially assured. As discussed under "The Inadequacy of Existing Regulatory Mechanisms," below, such emission cuts are not likely to happen absent significant changes in domestic and global energy policies. This section reviews the best available scientific information regarding the climate system and global warming observed to date, projections of future climate change, impacts to the polar bears observed to date, and projected impacts to polar bears.

## A. The Best Available Science Relating to Global Warming

That global warming as a result of anthropogenic greenhouse gas emissions (primarily carbon dioxide, methane, and nitrous oxides) is occurring, and will continue to occur, is no longer subject to credible scientific dispute. Two sets of recent publications, the Arctic Climate Impact Assessment's ("ACIA's") *Impacts of a Warming Arctic* (ACIA 2004a), and the Intergovernmental Panel on Climate Change's ("IPCC's") *Third Assessment Report – Climate Change 2001*, have recently synthesized the best available science on global warming.

The Arctic Council is a high-level intergovernmental forum that addresses the common concerns and challenges faced by the Arctic people and governments of the eight Arctic nations – Canada, Denmark/Greenland/Faroe Islands, Finland, Iceland, Norway, Russia, Sweden, and the United States, as well as six Indigenous Peoples organizations – Aleut International Association, Arctic Athabaskan Council, Gwich'in Council International, Inuit Circumpolar Conference, Russian Association of Indigenous Peoples of the North, and Saami Council, as well as official observers (ACIA 2004a). The Arctic Council commissioned the ACIA project and charged its working groups – Arctic Monitoring and Assessment Programme ("AMAP"), Conservation of Arctic Flora and Fauna ("CAFF"), and the International Arctic Science Committee ("IASC") - with its implementation. The efforts of hundreds of scientists over four years, as well as the special knowledge of indigenous peoples, contributed to the ACIA report. In sum, the ACIA (2004) is a comprehensively researched, fully referenced, and independently reviewed evaluation of Arctic climate change and its impacts (ACIA 2004a).

The IPCC was established by the World Meteorological Organization and the United Nations Environment Programme in 1988 (IPCC 2001a). The IPCCs mission is to assess available scientific and socio-economic information on climate change and its impacts and the options for mitigating climate change and to provide, on request, scientific and technical advice to the Conference of the Parties to the United Nations Framework Convention on Climate Change (IPCC 2001a). Since 1990, the IPCC has produced a series of reports, papers, methodologies, and other products that have become the standard works of reference on climate change (IPCC 2001a). The *Third Assessment Report* is the most current comprehensive IPCC reference and has built and expanded upon the IPCC's past products (IPCC 2001a).

These two synthesis reports represent the best available science on the subject of Arctic climate change. They are cited extensively below, along with specific instances of the peer-reviewed literature, in summarizing the important components of global warming most relevant to the plight of the polar bear. Additionally, numerous new peer-reviewed articles published in the preeminent scientific journals such as Science and Nature document and further refine the detection and attribution of climate change that has occurred to date, as well as projections of future warming (e.g. Stainford 2005; Stott 2004). The earth's climate is warming due to anthropogenic greenhouse gas emissions, and this warming will continue and accelerate, especially in the Arctic, if major reductions in emissions are not implemented very rapidly. There is simply no way that the FWS can credibly claim that such conclusions have not been established by the best available science.

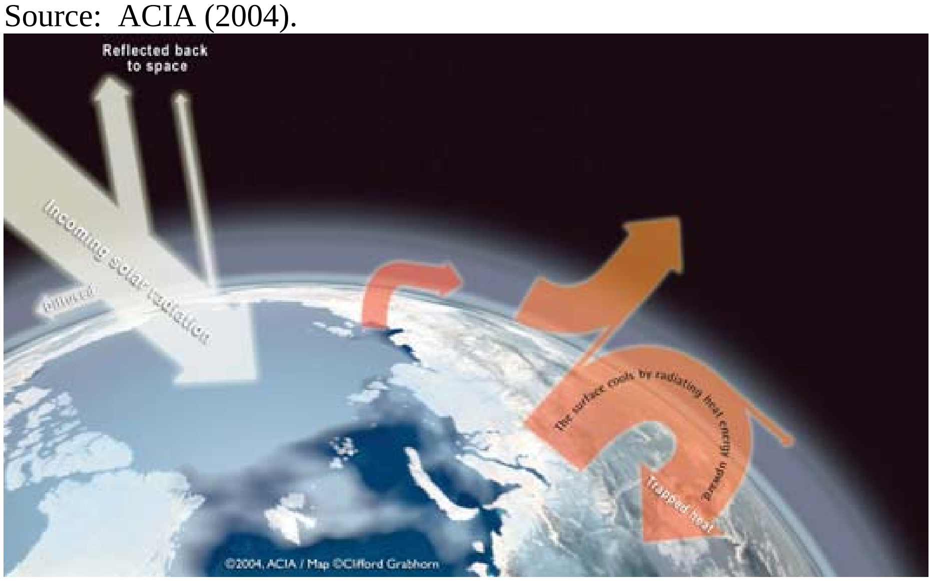
### B. The Climate System, Greenhouse Gas Concentrations, the Greenhouse Effect, and Global Warming

The earth absorbs heat in the form of radiation from the sun, which is then redistributed by atmospheric and oceanic circulations and radiated back to space (Albritton et al. 2001). The earth's climate is the result of a state in which the amount of incoming and outgoing radiation are approximately in balance (Albritton et al. 2001). Changes in the earth's climate can be caused by any factor that alters the amount of radiation that reaches the earth or the amount that is lost back into space, or that alters the redistribution of energy within the atmosphere and between the atmosphere, land, and ocean (Albritton et al. 2001). A change in the net radiative energy available to the global Earth-atmosphere system is called "radiative forcing" (Albritton et al. 2001). Positive radiative forcings tend to warm the Earth's surface while negative radiative forcings tend to cool it (Albritton et al. 2001).

Radiative forcings are caused by both natural and manmade factors (Albritton et al. 2001; ACIA 2004a). The level of scientific understanding of these different forcings varies widely, and the forcings themselves and interactions between them are complex (Albritton et al. 2001). Scientists now know, however, that the primary cause of global warming is society's production of "greenhouse gases" such as carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), and halocarbons that cause positive radiative forcings (Albritton et al. 2001; IPCC 2001a; ACIA 2004a). Greenhouse gases are, in fact, the radiative forcing mechanism that is currently best understood (Albritton et al. 2001).

The Enhanced Greenhouse Effect is caused by increasing concentrations of greenhouse gases in the earth's atmosphere. As greenhouse gas concentrations increase, more heat reflected from the earth's surface is absorbed by these greenhouse gases and radiated back into the atmosphere and to the earth's surface. Increases in the concentrations of greenhouse gases slow the rate of heat loss back into space and warm the climate, much like the effect of a common garden greenhouse (Albritton et al. 2001; ACIA 2004a; Figure 3). The higher the level of greenhouse gas concentrations, the larger the degree of warming experienced.

**Figure 3: The Enhanced Greenhouse Effect**
Source: ACIA (2004).



High levels of anthropogenic greenhouse gas emissions, primarily from the burning of fossil fuels for energy, are causing greenhouse gas concentrations to rise, creating the Enhanced Greenhouse Effect and leading to global warming. For about one thousand years before the Industrial Revolution, the amount of greenhouse gases in the atmosphere remained relatively constant (Baede et al. 2001). Since that time, greenhouse gas concentrations have increased (Baede et al. 2001). Scientists can attribute the increase to anthropogenic emissions by various methods (Baede et al. 2001). For example, the changing isotopic composition of atmospheric carbon dioxide over time reveals the origin of the increase, and the fact that the increased carbon dioxide concentrations are from the burning of fossil fuels for energy (Baede et al. 2001).

The primary greenhouse gases include carbon dioxide, methane, nitrous oxide, halocarbons, and ozone ($O_3$). The amount of warming that will be caused by a set amount of each compound is that compound's "global warming potential" (Albritton et al. 2001). Global warming potential is a measure of the amount of heat absorbed by a set amount of a given gas over a set period (Albritton et al. 2001). Global warming potentials are all expressed relative to that of carbon dioxide, for which the global warming potential is set as one (Albritton et al. 2001). Carbon dioxide is by far the most important greenhouse gas because anthropogenic emissions of carbon dioxide dwarf those of all other compounds (Albritton et al. 2001). While much smaller amounts of other greenhouse gases are emitted, these other gases can still make an important contribution to climate change because they have global warming potentials many times that of carbon dioxide (Albritton et al. 2001). Increases in major greenhouse gas concentrations and their contribution to global warming are reviewed below.

In 2001, the IPCC concluded that atmospheric concentration of carbon dioxide had increased by 31% since 1750, and that the present carbon dioxide concentrations have not been exceeded during the past 420,000 years and likely not during the past 20 million years (IPCC 2001a). The current rate of increase is unprecedented during at least the past 20 million years (IPCC 2001a). About three fourths of manmade carbon dioxide emissions come from fossil fuel burning, and most of the remaining emissions are due to land-use changes, primarily deforestation (IPCC 2001a).

Similarly, the atmospheric concentration of methane has increased by about 150% since 1750, continues to increase, and has not been exceeded during the past 420,000 years (IPCC 2001a). About half of current methane emissions are manmade, and there is also evidence that current carbon monoxide (CO) emissions are a cause of increasing methane concentrations (IPCC 2001a). Over a 100-year period, methane will trap about 23 times more heat than an equal amount of carbon dioxide (Albritton et al. 2001).

The atmospheric concentration of nitrous oxide has increased by about 17% since 1750, continues to increase, and has not been exceeded during at least the last 1000 years (IPCC 2001a). About a third of current nitrous oxide concentrations are manmade. Over a 100-year period, nitrous oxide will trap about 296 times more heat than an equal amount of carbon dioxide (Albritton et al. 2001).

Halocarbons are carbon compounds that contain fluorine, chlorine, bromine, or iodine (Albritton et al. 2001). Most types of halocarbons are produced exclusively by human activities (Albritton et al. 2001). Halocarbons that contain chlorine, like chlorofluorocarbons, ("CFCs") also cause depletion of the stratospheric ozone layer and are regulated under the Montreal Protocol (Albritton et al. 2001). The combined tropospheric abundance of ozone-depleting gases peaked in 1994 and is now declining slowly (Albritton et al. 2001). However, some compounds which have been promoted as substitutes for now-regulated CFCs are themselves greenhouse gases, and concentrations of these gases, such as hydrochloroflurocarbons ("HCFCs") and hydroflurocarbons ("HFCs") are now increasing (Albritton et al. 2001). There are many different types of halocarbons, which have global warming potentials that vary between 12 and 12,000 times that of carbon dioxide (Albritton et al. 2001).

Ozone is another important greenhouse gas found in both the troposphere, the portion of the atmosphere that begins at the earth's surface and extends from 8 to 14.5 kilometers (5 to 9 miles) high, and the stratosphere, the portion of the atmosphere that starts just above the troposphere and extends to 50 kilometers (31 miles) high (Albritton et al. 2001). Ozone is not directly emitted, but rather is formed from photochemical processes involving both natural gases and manmade emissions (Albritton et al. 2001). Because ozone persists in the atmosphere for only a short period of time varying from weeks to months, its role in radiative forcing is more complex and less certain than for more persistent greenhouse gases (Albritton et al. 2001). Whether ozone results in negative or positive radiative forcing depends strongly upon the altitude at which the ozone occurs.

On one hand, the <u>loss</u> of ozone from the <u>stratosphere</u> (a phenomenon popularly termed a "hole in the ozone layer") has resulted in negative radiative forcing that has offset some portion of the warming caused by other greenhouse gases (Albritton et al. 2001). However, the ozone layer is expected to rebound as a result of the Montreal Protocol, and the negative forcing caused by the current depressed levels of ozone in the stratosphere is expected to reverse (Albritton et al. 2001).

On the other hand, <u>increases</u> of ozone in the <u>troposphere</u> cause positive radiative forcing (Albritton et al. 2001). Ozone in the troposphere is in fact the third most important greenhouse gas after carbon dioxide and methane (Albritton et al. 2001). Tropospheric ozone is estimated to have increased by approximately 35% since the Industrial Revolution, though increases have varied by region (Albritton et al. 2001). Ozone concentrations respond relatively quickly to changes in the emissions of ozone precursors such as NO and $NO_2$ (the sum of which is denoted $NO_x$) and volatile organic compounds ("VOCs") (Albritton et al. 2001).

Other gases, such as $NO_x$, volatile organic compounds, and carbon monoxide are called indirect greenhouse gases because of their impact on the abundance of tropospheric ozone and other greenhouse gases such as methane (Albritton et al. 2001). These compounds interact and contribute to global warming in complex ways. For example, increases in $NO_x$ concentrations decrease methane concentrations but increase tropospheric ozone (Albritton et al. 2001). Moreover, deposition of the reaction products of $NO_x$ fertilizes the earth, thereby decreasing atmospheric carbon dioxide (Albritton et al. 2001).

Many other natural and human caused factors that are less understood than greenhouse gases contribute to positive or negative radiative forcing, including aerosol emissions, land-use changes, and changes in solar and volcanic activity, water vapor, and cloud cover (Albritton et al. 2001). Nevertheless, scientists now know that greenhouse gases are the most important force driving global warming, and that carbon dioxide is in turn the most important of the greenhouse gases (Albritton et al. 2001). Carbon dioxide emissions from fossil fuel burning are virtually certain[4] to remain the dominant control over trends in atmospheric carbon dioxide concentrations during this century (Albritton et al. 2001).

[4] IPCC documents use standardized confidence levels that represent the collective judgment of the authors regarding the validity of a conclusion (IPCC 2001a). "Virtually certain" means a greater than 99% chance that a conclusion is true (IPCC 2001a).

## C. The Arctic is Warming Much Faster than Other Regions

Due to its unique characteristics, the Arctic[5] has warmed and is projected to warm more rapidly than any other region on earth (ACIA 2004a; Anisimov et al. 2001). A number of interactions and feedbacks explain both why the Arctic is warming more rapidly than other regions and why Arctic warming has a large influence on warming in other regions (Anisimov et al. 2001; ACIA 2004a). Over a year's time, incoming energy from the sun is greatest near the equator and smallest near the poles (ACIA 2004a). Areas covered with snow and ice (the "cryosphere") also reflect a larger fraction of solar energy back into space than more temperate regions (ACIA 2004a). The atmosphere and oceans move energy from the tropics to the poles, resulting in polar regions that are warmer and tropical regions that are cooler than they would be without this circulation (ACIA 2004a). The Atlantic Ocean is the major carrier of the oceanic component of energy transfer, and is therefore critically important to Arctic warming (ACIA 2004a).

The first major interaction and feedback relating to Arctic climate change relates to surface reflectivity (ACIA 2004a). As Arctic temperatures warm, snow and ice begin to form later in the autumn and melt earlier in the spring (ACIA 2004a). Less snow and ice cover results in less reflectivity, because the land or water surfaces beneath the snow and ice are much darker and absorb more of the sun's energy than the snow or ice (ACIA 2004a). For example, sea ice reflects 85-90% of solar radiation, while ocean water reflects only 10% (ACIA 2004a). Greater heat absorption leads to more warming. This increased warming creates a self-reinforcing cycle by which global warming is amplified and the warming trend is accelerated (ACIA 2004a). This process is already underway in the Arctic (ACIA 2004a).

Another factor increasing Arctic warming is soot. Soot produced from the burning of fossil fuels and in particular from diesel exhaust is carried by winds and deposited in the Arctic (ACIA 2004a). The soot deposition slightly darkens the surface of the otherwise white snow and ice, further reducing surface reflectivity, increasing heat absorption, and therefore increasing global warming (ACIA 2004a). Soot in the atmosphere also increases solar absorption and contributes to warming (ACIA 2004a).

Scientists project that Arctic warming will be further accelerated by reflectivity changes that occur as boreal forests expand further northward and replace existing tundra (ACIA 2004a). Forests are taller, darker, and more textured than the relatively smooth tundra, and therefore absorb more radiation (ACIA 2004a). While the greater carbon intake of forests versus tundra may moderate this impact, scientists believe that the impacts from decreases in surface reflectivity are likely to outweigh the impacts from greater carbon uptake (ACIA 2004a).

The second feedback relates to greenhouse gas emissions in the Arctic itself (ACIA 2004a). Large amounts of carbon are currently trapped as organic matter in the permafrost that underlies much of the Arctic (ACIA 2004a). During the summer when the surface layer of permafrost thaws, organic matter in this layer decomposes, releasing carbon dioxide and methane into the atmosphere (ACIA 2004a). Warming increases release of these greenhouse gases, further increasing their atmospheric concentrations, and causing a feedback loop which amplifies the rate of warming (ACIA 2004a).

[5] IPCC and ACIA publications' general definition of the "Arctic" is the area within (i.e., north of) the Arctic Circle.

A longer term concern is the release of large amounts of methane, a potent greenhouse gas that traps about 23 times more than the same amount of carbon dioxide over a 100-year period. Large amounts of methane are currently stored in permafrost and at shallow depths in cold ocean sediments (ACIA 2004a). Even a relatively small rise in temperature of the permafrost or water at the seabed could initiate the release of this methane and greatly increase global warming.

The third major interaction and feedback increasing the rate of warming in the Arctic relates to ocean currents (ACIA 2004a). Solar energy is transported from the equator to the poles through globally connected movement of ocean waters driven primarily by differences in heat and salt content (ACIA 2004a). This movement is known as thermohaline circulation (ACIA 2004a). Currently, the Gulf Stream brings warm water and air to the North Atlantic, and provides much of the precipitation over northwestern Europe (ACIA 2004a). As waters move northward, they become cooler and denser, until they are heavier than the waters below and sink deep into the ocean (ACIA 2004a). Sinking of dense seawater pulls more warm waters northward, helping to provide a moderating influence in Europe, and explaining why locations in Europe are warmer than locations in North America that are at the same latitude (ACIA 2004a). Scientists believe that warming temperatures will affect the thermohaline circulation in several ways which, on the balance, will increase the rate of warming.

Overall, the average temperature in the Arctic has increased at almost twice the rate as that of the rest of the world (ACIA 2004a). The Arctic is not only warming faster than other regions due to these important interactions and feedbacks, but, as discussed further below, Arctic ecosystems and species such as the polar bear are also particularly vulnerable to the impacts of climate change (Albritton et al. 2001; ACIA 2004a).

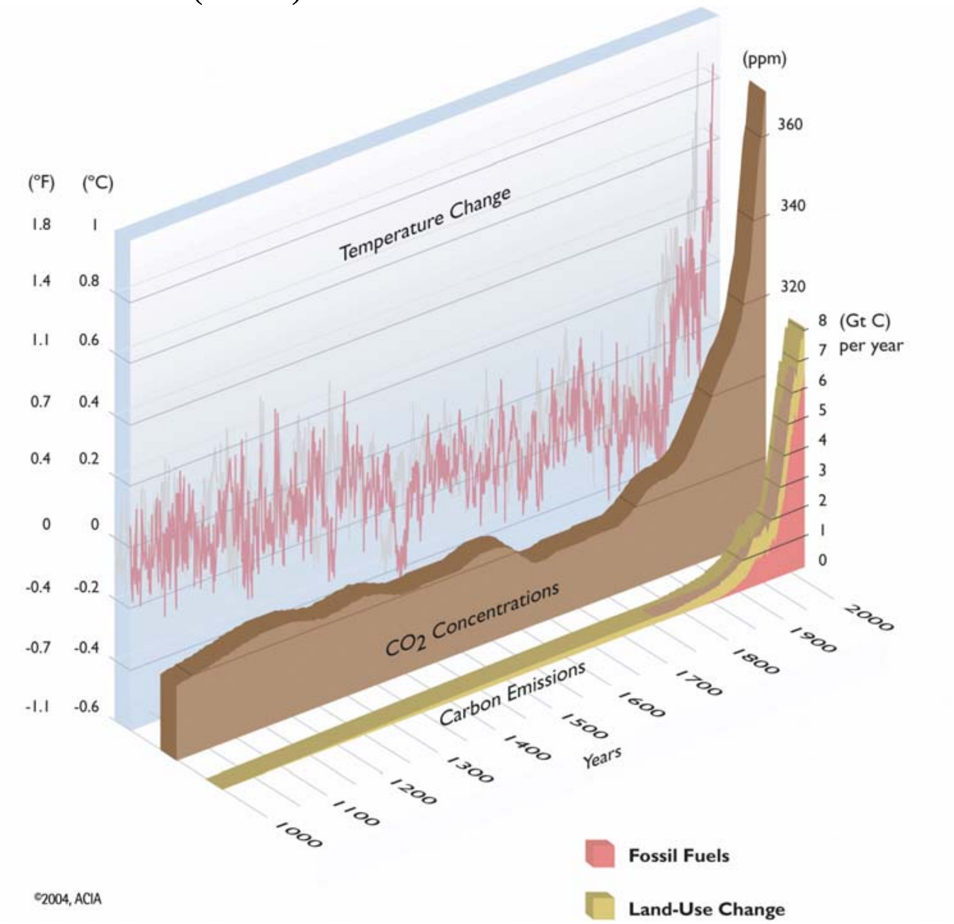
### D. Climate and Environmental Changes Observed to Date

The global average temperature has risen by approximately 0.6° C ± 0.2 C during the 20$^{th}$ Century (IPCC 2001a). There is an international scientific consensus that most of the warming observed has been caused by human activities (ACIA 2004a; IPCC 2001a), and that it is "likely"[6] that it is largely due, specifically, to emissions of greenhouse gases (IPCC 2001a). Carbon dioxide emissions, carbon dioxide concentrations, and temperature over the last 1,000 years are correlated (ACIA 2004a; Figure 4 (next page)). Growth rings from larch trees in northern Siberia show that mean temperatures during the 20$^{th}$ century were the highest in 1,000 years (Albritton et al. 2001). Global climate has changed in other ways as well. For example, precipitation has increased by 0.5 to 1% per decade in the 20$^{th}$ century over most mid- and high latitudes of the Northern Hemisphere continents, and to a lesser degree over the tropical land areas in the northern hemisphere (IPCC 2001a).

As discussed above, the rate of climate change to date has been greatest in the Arctic. While there is considerable variability of changes within the Arctic (Albritton et al. 2001; ACIA 2004a; Derocher et al. 2004), changes in some areas dwarf global averages. In Alaska and western Canada, winter temperatures have increased by as much as 3-4° C (5.4-7.2° F) over the last 50 years (ACIA 2004a). In extensive areas of the Arctic, air temperature over land has increased by as much as 5° C (9° F) over the 20$^{th}$ century (Anisimov et al. 2001).

[6] For the IPCC, "likely" means a 66-90% chance that a conclusion is true (IPCC 2001a).

**Figure 4: 1000 Years of Changes in Carbon Emissions, Carbon Dioxide Concentrations, and Temperature**
Source: ACIA (2004:3).




Climate change includes much more than simply changes in temperature. Precipitation has increased in the Arctic (Anisimov et al. 2001; ACIA 2004a), perhaps by as much as 8% in the past 100 years (ACIA 2004a). Rain on snow events have also increased significantly across much of the Arctic, with increases of 50% recorded over the past 50 years in western Russia (ACIA 2004a). At the same time, snow cover has decreased by about 10% over the Northern Hemisphere as a whole since 1972 (Serreze et al. 2000). There is also evidence of a general decrease in snow depth in Canada since 1946, especially in the spring, and of decreases in winter snow depths over European Russia since the beginning of the last century (Serreze et al. 2000).

A key climate indicator of particular relevance to the polar bear is the extent and timing of formation and break-up of sea ice. The extent of sea ice is a key indicator of climate change. It also significantly influences climate by affecting surface reflectivity, cloudiness, humidity, exchanges of heat and moisture at the ocean surface, and ocean current and thus likely exerts a substantial influence on climate change related to global warming (ACIA 2004a).

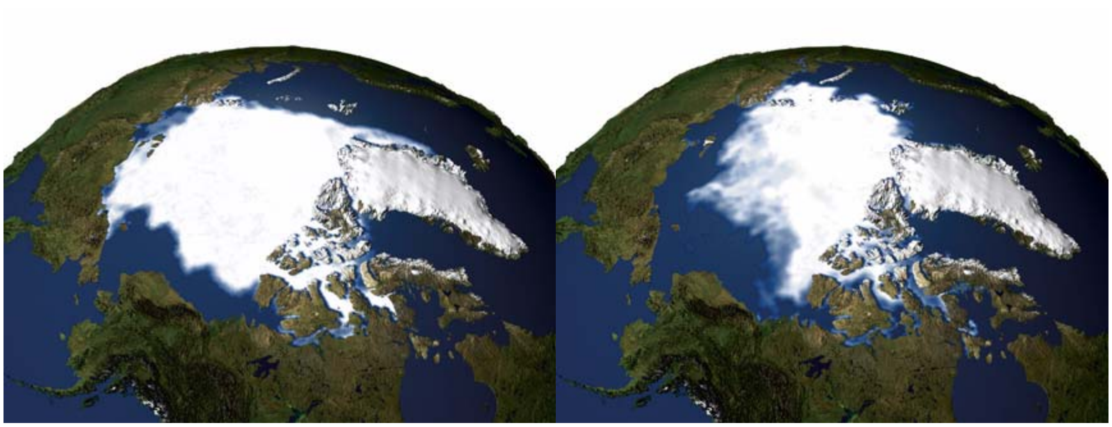
The ACIA (2004) reported that the annual average sea-ice extent has decreased by about 8%, a decrease of nearly one million square kilometers of sea ice, an area larger than all of Norway, Sweden, and Denmark combined, over the past 30 years. Other authors have reported that sea-ice extent has decreased by approximately 2.8% per decade over the 1978-1996 period (Parkinson et al. 1999; Albritton et al. 2001). Most recently, however, estimates have been revised upwards based on updated satellite data (Comiso 2005). Comiso (2005:52) reports

> We are currently observing rapidly retreating perennial sea ice during the 25-year observational period when the surface temperature concurrently went up by about 1°C. An update of data used in previous reports shows that the perennial ice cover continued to decline at an even faster rate of 9.2% per decade, while the surface temperature has been steadily going up in most places….

Decreases in observed sea ice have been greatest in the Kara and Barents Seas, followed by the Seas of Okhotsk and Japan, the Arctic Ocean, Greenland Sea, Hudson Bay, and Canadian Archipelago (Parkinson et al. 1999).

The decline sea-ice extent has been greater in summer than in winter, with a 15-20% loss of late-summer ice coverage (ACIA 2004a). Significant interannual variability has also been observed, but September 2002 had the smallest extent of Arctic sea-ice cover on record, with September 2003 nearly as low (ACIA 2004a). Declines in sea ice from 1979 to 2003 are startling (Figure 5). Analysis of the melting trend reveals that it is much larger than would be expected from natural climate variations (Anisimov et al. 2001). This melting trend is accelerating (ACIA 2004a). Abnormally large open water areas in the late summer in the area of the Beaufort, Chukchi, and Siberian Seas have also been observed in 2002, 2003, and 2004 (Comiso 2005).

**Figure 5: Observed Sea Ice, September 1979 Compared to Observed Sea Ice, September 2003**
Source: ACIA 2004a:25.



Sea-Ice Extent in September, 1979 | Sea-Ice Extent in September, 2003

The timing of sea ice freeze-up and break-up and the length of the ice season is another critical variable of immediate concern for the polar bear. As reported in Derocher et al. (2004) and discussed further below, break-up of the annual ice is now occurring approximately 2.5 weeks earlier than it did 30 years ago in western Hudson Bay in Canada. Gough et al. (2004) also found a trend towards earlier break-up in southwestern Hudson Bay, immediately south of the area examined by Derocher et al. (2004) and Stirling et al. (1999). Another study has found an increase of 5.3 days (8%) per decade in the duration of summer melt over a large fraction of the perennial Arctic sea ice from 1979 to 1996 (Smith 1998; Anisimov et al. 2001). Comiso (2005) has most recently reported that the period of sea-ice melting has increased by an average of 13.1 days per decade over sea-ice regions as a whole.

The thickness of sea ice has decreased by 15-20% overall in recent decades, with some areas showing reductions of up to 40% between the late 1960s and late 1990s (ACIA 2004a), though there is variability throughout the Arctic (Anisimov et al. 2001). Rothrock et al. (1999) found a mean decrease in ice thickness of 1.3 m in most of the deep water portion of the Arctic Ocean, from 3.1 m in 1958-1976 to 1.8 m in the 1990s. The greatest decrease occurred in the central and eastern Arctic (Rothrock et al. 1999). Ice composition has also changed as multi-year ice has been reduced in winter (Anisimov et al. 2001).

The sea-surface temperature in the Arctic basin has increased by 1° C over the past 20 years, the area of warm Atlantic water in the polar basin has increased by almost 500,000 $km^2$, and field measurements in 1994 and 1995 showed a consistent Arctic seawater warming of 0.5-1° C (Anisimov et al. 2001).

Indigenous people have also reported changes in ice conditions and extent. Scientists conducted interviews with 52 hunters in eastern Greenland in 1999 (Jessen 2002). These hunters reported changes in the ice conditions within the past 5-6 years (Jessen 2002). The zone of land-fast ice along the coasts was described as narrowing, which in some cases forced the hunters to drive their dog sleds via inland passages to avoid passing around capes during the spring hunt (Jessen 2002). In 1999, the unusually early break-up of the land-fast ice in June allowed the hunters in one eastern Greenland municipality to start the boating season early (Jessen 2002). In one southeastern Greenland municipality, the unusually light ice conditions prevented the hunters from going south by sled in the spring, but made it easier for them to go north by boat during the summer (Jessen 2002).

Changes in permafrost have also been recorded as temperatures warm (Anisimov et al. 2001). Thawing of permafrost has caused major erosion and landslide problems in the Mackenzie basin, and has caused major landscape changes from forests to bogs, grasslands, and wetland ecosystems in Alaska (Anisimov et al. 2001). In central and western Canada and in Alaska, contraction in the extent of permafrost has occurred during the 20th century (Anisimov et al. 2001). Temperatures at the top of permafrost along a several hundred kilometer north-south transect in central Alaska warmed by 0.5-1.5° C between the late 1980s and 1996 (Anisimov et al. 2001). On the north slope of Alaska and in northwestern Canada, the temperature-depth profile indicates a temperature rise of 2-4° C over the past 100 years (Anisimov et al. 2001).

Changes in terrestrial ecosystems including northward movement of the treeline, reduced nutritional value of browsing for caribou and moose, decreased water availability, and increased forest fire tendencies have also been observed (Anisimov et al. 2001). Plant species composition, especially forbs and lichen on the tundra, have altered. Rising temperatures have lengthened the growing season by 20% for agriculture and forestry in Alaska, and boreal forests are expanding northward at a rate of about 100 km per degree Celsius that the climate warms (Anisimov et al. 2001).

While it is difficult to ascribe any specific observed change to global warming rather than short-term variability, researchers' ability to attribute climactic conditions and events to greenhouse gas emissions is rapidly improving. In total the observed changes compel the conclusion that the impacts of global warming are already being felt. As Comiso (2005:52) stated, "Global warming in the Arctic is to a certain degree already manifested by observed retreat of ice and snow, melt of glaciers, thawing of permafrost, and retreat of the sea ice cover."

In summary, temperatures have already warmed 5° C in some areas of the Arctic. This warming has been accompanied by widespread decreases in the extent of the sea ice, particularly in summer, as well as earlier break-up dates and a longer melting season. Precipitation has increased while snow cover has decreased. Permafrost is melting. Vegetation is shifting northward. In some areas polar bears are already suffering from global warming and reductions in sea ice. Specific impacts observed to date to polar bear populations from this warming are reviewed below.

### E. Global Warming is Projected to Accelerate

There is no credible scientific dispute that global warming will continue and accelerate if greenhouse gas emissions are not reduced. All climate models predict significant warming in this century, with variation only as to the rate and magnitude of the projected warming (ACIA 2004a).

Determining the degree of future climate change requires consideration of two major factors: (1) the level of future global emissions of greenhouse gases, and (2) the response of the climate system to these emissions ("climate sensitivity")(ACIA 2004a). Decades of research have generated a large body of information relating to each of these factors (ACIA 2004a).

Because hard data are not available for events that have not yet occurred, the future level of society's greenhouse gas emissions must be projected. The IPCC has produced a Special Report on Emissions Scenarios ("SRES") (Nakićenović et al. 2000) that describes a range of possible emissions scenarios based on how societies, economies, and energy technologies may evolve, in order to carefully study a range of possible scenarios (ACIA 2004a; Albritton et al. 2001). The IPCC has produced 40 scenarios using four different narrative storylines that consistently describe the relationship between societal forces driving emissions and their evolution (Albritton et al. 2001). The scenarios represent the best available information regarding future levels of emissions.

In its flagship report on climate change in the Arctic, the ACIA (2004) utilized the IPCC's "B2" scenario. Of the scenarios developed by the IPCC, "B2" falls slightly below the middle of the range of future emissions. The "B2" scenario

> assumes a world concerned with environmental protection and social equity, with solutions focused at the local and regional levels. It is a world in which global population grows to reach 10.4 billion by 2100, there is an intermediate level of economic development, and there is diverse technological change around the world. In a B2 world, by the year 2100, coal supplies 22% of the primary energy, and 49% of the world's energy is derived from sources that emit no carbon dioxide (ACIA 2004a:126).

The ACIA (2004) also used the IPCC's "A2" scenario for some calculations. By contrast, the "A2" scenario assumes a world more concerned with economic growth than in the "B2" scenario (ACIA 2004a). The "A2" scenario assumes a global population of 15 billion by the year 2100, where coal provides 53% of the world's primary energy and sources that emit no carbon dioxide only 28% (ACIA 2004a). The ACIA (2004a)'s primary use of the "B2" scenario and secondary use of the "A2" scenario does not imply a judgment that these are the most likely scenarios, but instead reflects the practical limits of conducting such a large assessment (ACIA 2004a).

The SRES scenarios are all "likely" in the sense that they represent balanced and conservative projections of future emissions levels. All SRES scenarios assume that greenhouse gas emissions will be reduced from current levels by a wide range of government policies[7] (Albritton et al. 2001). The SRES scenarios do not represent "worst case" scenarios, but rather a wide range of possible futures based on the best available information. The conservative nature of the SRES scenarios is also demonstrated by the fact that the official United States forecast predicts no growth at all in the use of renewable, non-carbon emitting energy sources from their current 8% market share through the year 2025 (EIA 2004), while the two SRES scenarios used by ACIA (2004), "B2" and "A2," assume an increase in non-carbon emitting sources to 49% and 28% by 2100, respectively.

Computer models have been developed by research centers around the world to make projections of future climate change. A computer model is a simplified mathematical representation of the Earth's climate system (Albritton et al. 2001). The accuracy of a model's predictions hinge on the level of understanding of the physical, geophysical, chemical and biological processes that govern the climate system (Albritton et al. 2001). In recent years scientists have made large improvements in the predictive power of climate models, which have become extraordinarily complex and require the most powerful computers available (Albritton et al. 2001), or very large numbers of individual computers (Stainford et al. 2005). Confidence in the models has also increased due to the ability of several models to accurately reproduce warming trends in the 20th century (Albritton et al. 2001).

The ACIA (2004) used five different models from leading research centers around the world. The models used by ACIA (2004) are from the Canadian Centre for Climate Modeling and Analysis, Canada ("CGCM2"), the National Center for Atmospheric Research, United States ("CSM_1.4"), the Max-Planck Institute for Meteorology, Germany ("ECHAM4/OPYC3"), the Geophysical Fluid Dynamics Laboratory, United States ("GFDL-R30_c"), and the Hadley Centre for Climate Prediction and Research, United Kingdom ("HadCM3").

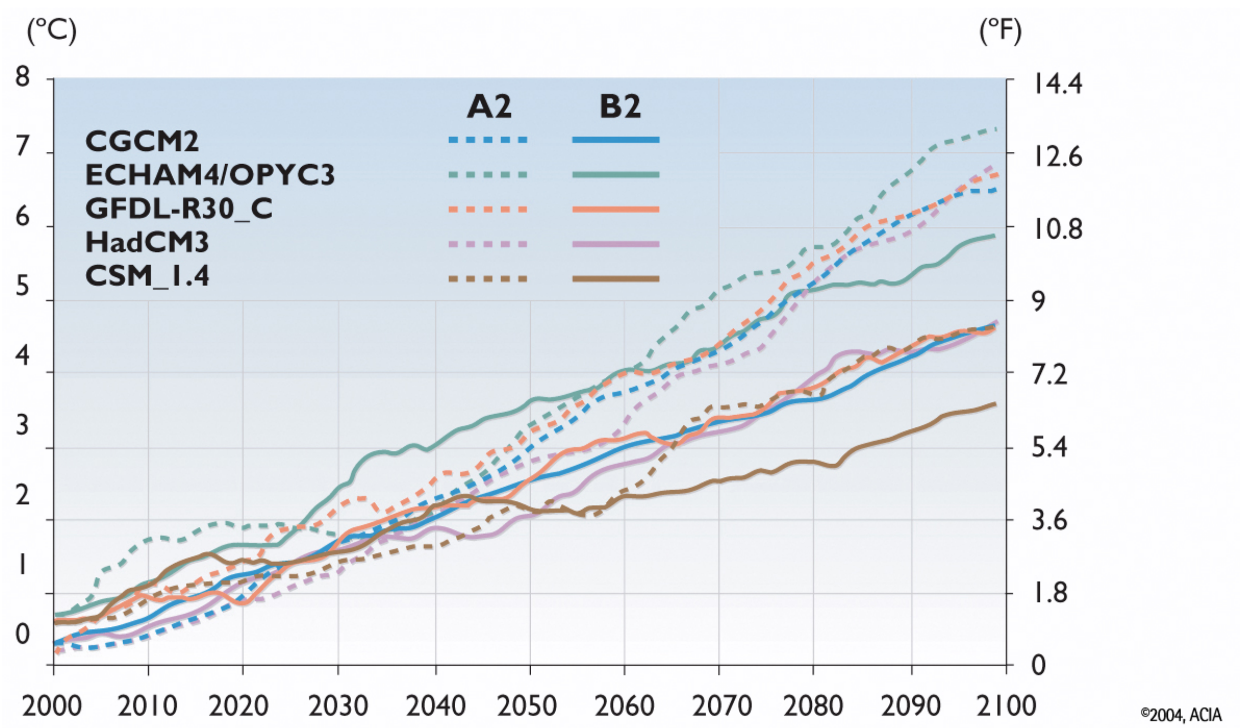
These models make different assumptions regarding how various aspects of the climate system will respond to increased greenhouse gas concentrations and warming temperatures. These differing assumptions are expressed as climate sensitivity, defined as the equilibrium response of global mean temperature to doubling levels of atmospheric carbon dioxide (Stainford et al. 2005). The IPCC (2001a, b and c) used climate sensitivities of 1.3-5.8K for projections of warming from 1990-2100 (Stainford et al. 2005). Results from the recent climate*prediction*.net experiment indicate that much larger climate sensitivities of up to 11.5K are possible (Stainford et al. 2005). Larger climate sensitivity measures result in much higher amounts of projected mean global warming, and warming in the Arctic is much higher than mean global warming. Therefore, current models may in fact substantially underestimate Arctic warming that will result from greenhouse gas emissions. If this is the case, then warming and melting of sea ice in the Arctic will be more extreme and more rapid than currently projected, resulting in a much shorter extinction trajectory for the polar bear.

The ACIA (2004), using the "B2" emissions scenario and the five models described above, as well as information from additional sources, represents the best available science on global warming in the Arctic. The results discussed below are primarily from ACIA (2004), though other literature is included and cited as relevant.

[7] While none of the SRES scenarios assume full implementation of the United Nations Framework Convention on Climate Change or the emissions targets of the Kyoto Protocol, as discussed on pages 57-59, below, the overall targets of the Kyoto Protocol for 2012 are highly unlikely to be met, and, even if they were, would not undermine the validity of the SRES scenarios.

Despite some variation among climate models and some remaining uncertainty regarding climate sensitivity, the salient point (as pointed out by Derocher et al. (2004)) is that all models predict a warming climate in the relatively near future; the differences in the models are primarily only in the rate of change and occasionally geographic variation in the strength and timing of effects (Albritton et al. 2001; ACIA 2004a). Even using the lowest emissions scenario and the model that generates the least warming in response to atmospheric composition leads to a projection of warming in this century more than double that experienced in the last (ACIA 2004a). All models project that the world will warm significantly as a result of human activities and that the Arctic is likely to experience this warming particularly early and intensely (ACIA 2004a; Figure 6).

**Figure 6: Projected Arctic Surface Air Temperature 2000-2100**
60° N – Pole: Change from 1981-2000 average
Source: ACIA (2004a:27).




Using an average of the five models' predictions and the "B2" scenario, ACIA (2004) projects that annual average temperatures will rise across the entire Arctic, with increases of approximately 3-5° C over the land areas and up to 7° C over the oceans. Winter temperatures are projected to rise even more significantly, with increases of approximately 4-7° C over land areas and approximately 7-10° C over oceans (ACIA 2004a). Year-to-year variability is also projected to be greater in the Arctic than in other regions (ACIA 2004a).

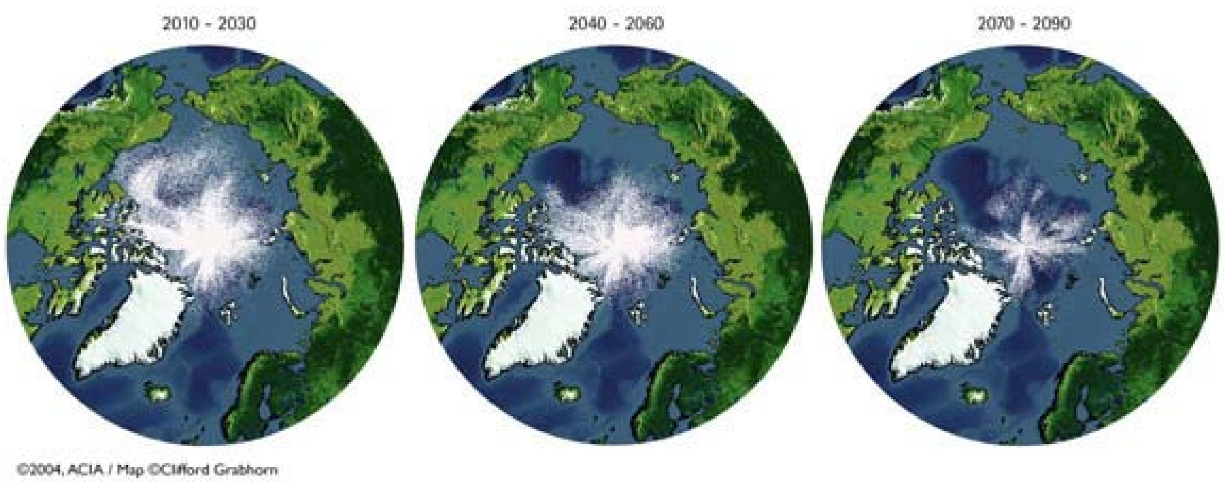
Most recently, New (2005) projected that the average global temperature will have risen 2° C above pre-industrial levels sometime between 2026 and 2060, a result that is consistent with the results of the ACIA (2004) discussed above. A 2° C rise in average global temperature will translate into an average Arctic temperature increase of 3.2°-6.6° C, which will be greatest in winter (4°-10° C) and less in summer (1.5°-3.5° C) (New 2005).

Precipitation is projected to increase by approximately 20% over the Arctic as a whole by the year 2100, with most of the increase falling as rain (ACIA 2004a). The increase is projected to be most concentrated over coastal regions and in the winter and autumn (ACIA 2004a). During the summer, precipitation over northern North America and Chukotka, Russia is projected to increase. During the winter, precipitation is expected to increase over all land areas except southern Greenland (ACIA 2004a).

Arctic snow cover over land is projected to decrease by 10-20% by the end of this century, in addition to the approximately 10% decline already observed over the past three decades (ACIA 2004a). The decreases are projected to be greatest in April and May, suggesting a further shortening of the snow season (ACIA 2004a). Snow quality changes are also predicted, including an increase in thawing and freezing in winter that leads to ice layer formation (ACIA 2004a).

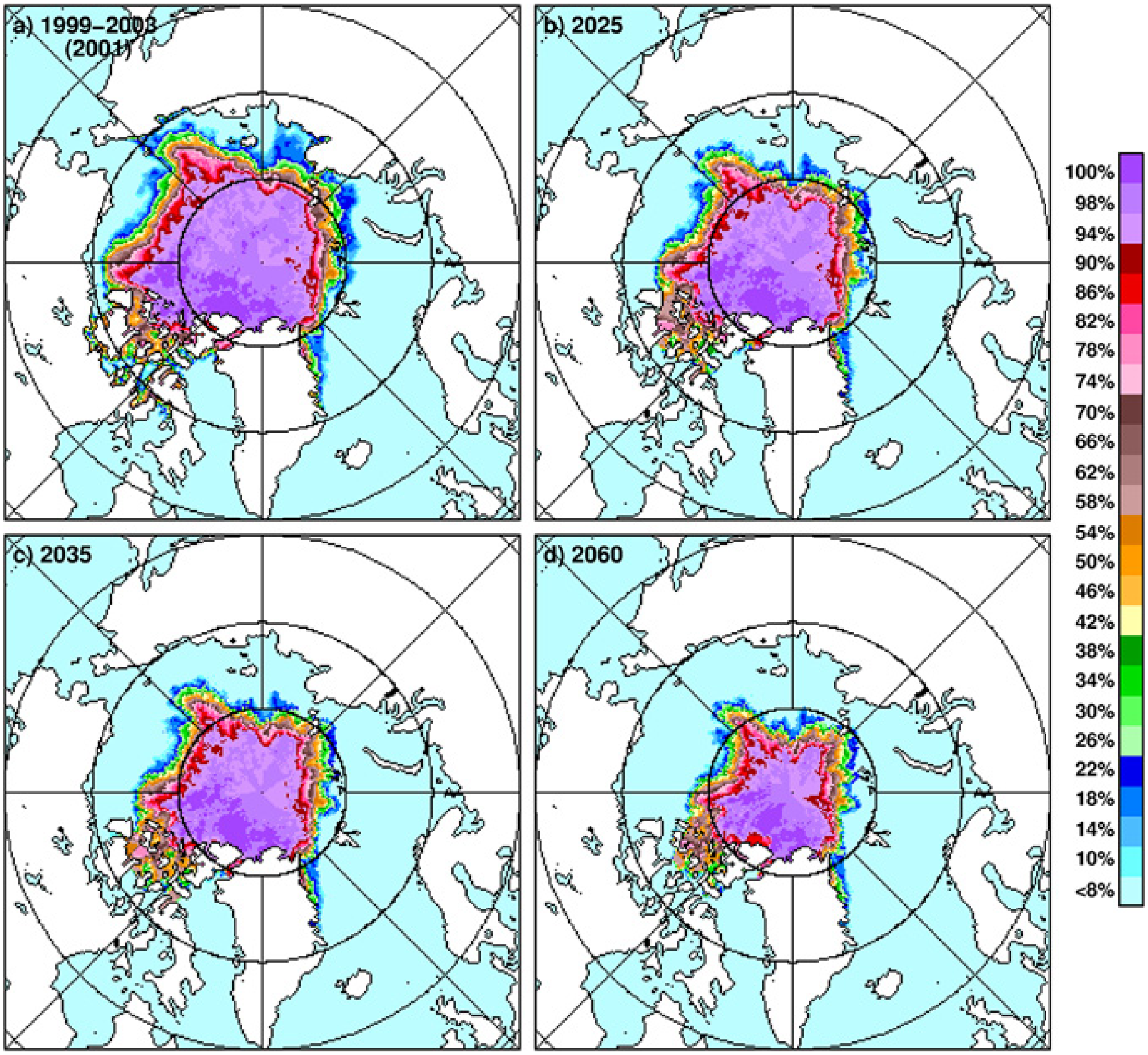
Additional losses of approximately 10-50% in annual average Arctic sea-ice extent are projected by the end of this century (ACIA 2004a). Loss of sea ice during the summer will be greater than the average annual decrease (ACIA 2004a). The average of projections of the five models noted above yields a greater than 50% decline by the end of the century, with some models predicting nearly complete disappearance of summer sea ice over the same time period (ACIA 2004a; Figure 7). It is important to bear in mind that this projection is from the B2 scenario which falls slightly <u>below</u> the middle of the range of emissions projections (ACIA 2004a), and using potentially understated measures of climate sensitivity. Actual impacts will likely be even greater. As discussed above, reductions in sea-ice cover also cause a critical feedback that will increase regional and global warming by reducing the reflectivity of the Earth's surface (ACIA 2004a).

**Figure 7: Projected Ice Extent (5-Model Average for September)**
Source: ACIA (2004:30).




Another recent study has projected the <u>average</u> of the Arctic <u>perennial</u> ice cover based on 25 years of continuous and spatially detailed satellite data (Comiso 2005), and the recent conclusion that a 2° C global warming will occur between the years 2026 to 2060 (New 2005). The results show "ever increasing open ocean areas in the Beaufort, Siberian, Laptev and Kara Seas. The impact of such a largely increasing open water could be profound. It could mean changes in the ocean circulation, marine productivity, ecology, ocean circulation and the climate of the region" (Comiso 2005:53; Figure 8). This study also revealed that for each 1° C increase in surface temperature (global average), the area of the average perennial ice cover decreases by about 1.48 million $km^2$, an area over three times the size of the state of California (Comiso 2005).

**Figure 8: Current and Projected Average Perennial Ice Concentration**
Source: Comiso (2005:53).




(a) color coded map of the average of the Arctic perennial ice cover from 1998 to 2003; plus projections of a five-year running average of the perennial ice concentration data from 1978 to 2003 for the years (b) 2025; (c) 2035; and (d) 2060.

Statistical analyses indicate that at a 95% confidence level, the trend in the decrease in the perennial ice area projected in Figure 8 is between -5.7% and -12.5% per decade (Comiso 2005). Moreover, the accuracy of these projections is thus far borne out by most recent satellite observations:

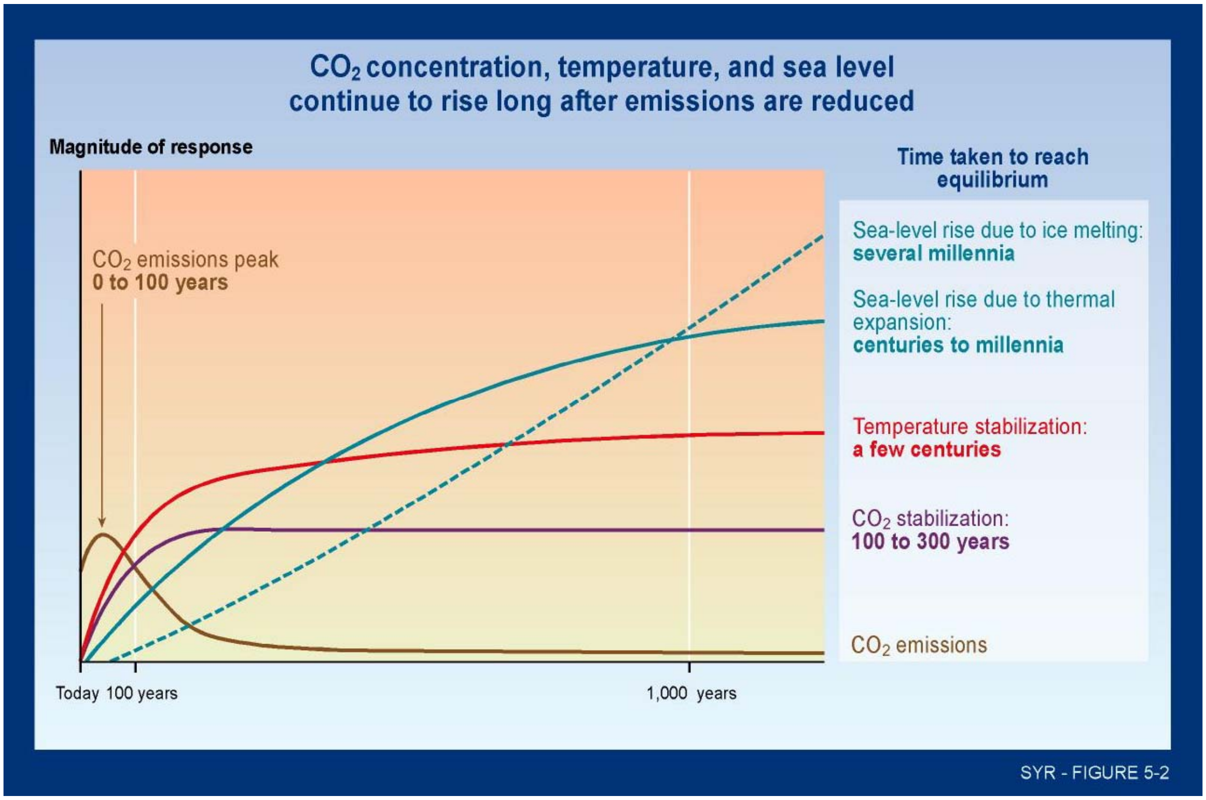
> It is interesting to note, that the general characteristics of the perennial ice cover in 2002 to 2003 are consistent with the predictions of the Comiso (2002) study. Our current prediction is also showing good consistency with the perennial ice cover in 2004, the extent of which appears to be the second lowest during the satellite era. It should also be

noted that the projected ice distributions provide patterns which are similar to those projected by some models (e.g. Johannessen et al. 2004) (Comiso (2005:52).

Regional changes in sea ice may be even more extreme. One first-generation coupled general circulation model examined by Gough and Wolfe (2000) indicates that sea ice will virtually disappear from Hudson Bay in Canada by the year 2050.

The world is already committed to some level of continued warming and climate change for centuries to come, due to the interactions between variables including greenhouse gas emissions, total greenhouse gas levels in the atmosphere, temperature change and ice melting (IPCC 2001c; Figure 9). Slow transport of heat into the oceans and slow response of ice sheets are largely responsible for the long time periods needed to reach a new climate system equilibrium (IPCC 2001c). The sooner greenhouse gas emissions are stabilized, and the lower the level at which they are stabilized, the smaller the overall temperature increase and sea-level rise will be (IPCC 2001c).

**Figure 9: Relationships Between Carbon Dioxide Concentrations, Temperature, and Sea-Level Rise**
Source: IPCC (2001(c):Figure 5.2).




Moreover, stabilization of carbon dioxide emissions at current or near-current levels will not lead to stabilization of carbon dioxide atmospheric concentrations (IPCC 2001c). Stabilization of carbon dioxide concentrations at any level requires eventual reduction of global carbon dioxide net emissions to a small fraction of the current emission level (IPCC 2001c). The lower the chosen level for stabilization, the sooner the decline in global carbon dioxide emissions needs to begin (IPCC 2001c).

Even after stabilization of the atmospheric concentration of carbon dioxide, surface air temperature is projected to continue to rise by a few tenths of a degree per century for a century or more (IPCC 2001c; Figure 9). Sea level is projected to continue to rise for many centuries (IPCC 2001c; Figure 9).

## F. Observed Impacts to Polar Bears from Global Warming

Over thirty years ago, Lentfer (1972), noted that a general warming trend had been observed in the Arctic prior to 1950[8], and that the polar bear could be adversely impacted by warming via changes in the sea ice and snow cover. While not attributing observed climate changes to human activities, Lentfer (1972:169) wrote prophetically:

> A general warming of the Arctic could adversely affect denning. Changing ice conditions because of a warming climate could result in fewer bears reaching some of the more favorable denning areas. Also, Vibe (1967) has pointed out that bears and ringed seals, their principal food, require a relatively stable Arctic or sub-Arctic climate without periods of thawing and melting of snow during the winter, in order to successfully den and produce offspring. Warming of the Arctic would reduce the extent of such favorable areas. Disappearance of the ice cover because of air temperature anomalies, a possibility described by Budyko (1966), would have a severe impact on denning and, in fact, the food chain supporting the polar bear….

Several decades later, Lentfer's (1972) predictions are coming to pass due to anthropogenic climate change.

Hudson Bay in Canada has been called the vanguard of Arctic change and an ideal location to study the impacts of global warming due to its southern location and placement on a divide between a warming and a cooling region (AMAP 2003). Hudson Bay is the site of the first documented evidence of major and ongoing impacts to polar bears from global warming.

Over a decade ago, Stirling and Derocher (1993) predicted an array of impacts to polar bears from global warming, including reduced abundance of and access to seals and effects on the marine ecosystem that influence productivity. Stirling and Derocher (1993) noted that changes in polar bear parameters such as declining body condition, lowered reproductive rates, and reduced cub survival were already present in the Western Hudson Bay population, but that it was not yet possible to ascribe these changes to global warming. Over the next decade and beyond, these researchers and their colleagues have continued to document the relationships between climate, sea ice, and polar bear physiological and demographic parameters. In a 19-year study discussed below, Stirling et al. (1999) established the link between global warming and observed impacts to polar bear physical and reproductive parameters, including body condition and natality.

Hudson Bay, together with the smaller James Bay, is a large body of salt water located in northern Canada (Gough et al. 2004; Figure 10 (next page)). Hudson Bay borders three provinces, Manitoba, Ontario, and Quebec, and as well as the territory of Nunavut (Gough et al. 2004). Most of

[8] While not all of the scientific beliefs of the time are still accepted today, Lentfer (1972) and his contemporaries were quite correct about this observed warming trend: the IPCC (2001) reports that most of the warming that has occurred during the 20th century has come during two periods, from 1910-1945, and from 1976-2000.

Hudson Bay is separated from the rest of the ocean by land masses, and is connected only through narrow channels at the north end of Foxe Basin and Hudson Strait (Gough et al. 2004; Figure 10). As a result, Hudson Bay behaves like a relatively closed system (Gough et al. 2004). Hudson Bay has an average depth of 120 m, and is ice-free in the summer and freezes over in the winter (Gough et al. 2004). Thus, in the summer Hudson Bay creates a general marine climate in the surrounding area, while in the winter it is insulated by ice and snow and permits cold polar air masses to extend south into central Canada (Gough et al. 2004). Typically it is completely covered in ice from January to May and is ice-free from mid-August to late October (Gough et al. 2004), with intermediate levels of ice forming or breaking up in the intervening periods. Break-up begins first in James Bay, at the southern end of Hudson Bay close to the western shoreline, due to warm winds, and also in the eastern region of Hudson Bay, from spring runoff (Gough et al. 2004). Ice that melts in the southern part of Hudson Bay is initially replaced through ice advection from the north (Gough et al. 2004). As a result, the last place to break up in the spring is often the southwestern region of Hudson Bay (Gough et al. 2004), part of the Southern Hudson Bay polar bear population's territory and south of the terrestrial denning area of the separate Western Hudson Bay polar bear population. Gough et al. (2004) found a trend towards earlier break-up of the ice in the southwestern region of Hudson Bay and the northwestern region of James Bay that is consistent with the results of Stirling et al. (1999) and Derocher et al. (2004), discussed below.

**Figure 10: Western Hudson Bay with Boundaries of the Western Hudson Bay (WH), Southern Hudson Bay (SH), and Foxe Basin (FB) Polar Bear Populations**


In Western Hudson Bay, break-up of the annual ice is now occurring approximately 2.5 weeks earlier than it did 30 years ago (Derocher et al. 2004). This has shortened the amount of time that bears are able to feed on seals during late spring and early summer, the most important time of the year for feeding purposes (Derocher et al. 2004). There is a highly significant relationship between break-up of the sea ice and condition of the bears when they come ashore (Derocher et al. 2004). The earlier they are forced to come ashore, the less fat they have been able to store, and consequently the less fat reserves they will have to fast upon during the 4-month open water period (Derocher et al. 2004). Declining reproductive rates, subadult survival, and body mass are already occurring due to the progressively earlier break-up of the sea ice caused by an increase in spring temperatures (Derocher et al. 2004).

Researchers have been studying polar bears in the Western Hudson Bay population for decades. In 1993 Stirling and Derocher predicted adverse impacts on polar bears including decreased body condition, lowered reproductive rates, and reduced survival of cubs. At that time most of those changes were already detectable in the Western Hudson Bay population but not yet attributed to global warming (Stirling and Derocher 1993). In a landmark 19-year study, Stirling et al. (1999) attributed declines in polar bear body condition and reproductive rates in the Western Hudson Bay population to global warming. The study area was defined as the management boundaries of the Western Hudson Bay population (Stirling et al. 1999), shown in Figure 10. Nineteen years of data (1981 through 1998) were available for parameters including the duration and extent of ice cover for Hudson Bay, the dates of break-up and freeze-up of the annual ice in Hudson Bay, adult polar bear body condition, and polar bear reproductive variables (Stirling et al. 1999). "Break-up" was defined as the date on which the ice had disintegrated to below 50% cover, and "freeze-up" was defined as the date by which ice had formed and consolidated once again to 50% cover (Stirling et al. 1999). The 50% threshold is appropriate because polar bears tend to move from the sea ice to land once the sea-ice concentration drops below 50% (Derocher et al. 2004).

Data for ice cover in Hudson Bay itself over the study period showed a long-term, but nonsignificant trend toward decline in total ice cover (Stirling et al. 1999). Stirling et al. (1999) reported that variation in the total extent of ice cover between years resulted from changes in the timing of break-up, freeze-up, or both. Thus, Stirling et al. (1999) reported that in years with a large ice extent, the date of break-up tended to be later while the date of freeze-up was earlier, and the opposite occurred in years with relatively low ice extent. In the Western Hudson Bay study area, data from the 20-year period from 1979-1998 showed an overall trend that approached significance for break-up occuring earlier (Stirling et al. 1999). For the 19-year period from 1979-1997, no trend was found for the timing of freeze-up. Overall, there was an increase, though not statistically significant, in the number of ice-free days through the duration of the study, primarily due to the trend for an earlier break-up (Stirling et al. 1999). Stirling et al. (1999) also found that the date of break-up was significantly later in the 1980s than it was in the 1990's.

Stirling et al. (1999) found a highly significant correlation between the mean date on which radio-collared female polar bears came ashore and the timing of break-up. Between 1991 and 1998, female bears with radio collars came ashore an average of 24.6 ± .87 days after break-up, indicating that they remained on the ice to hunt seals well after a significant reduction in total ice cover (Stirling et al. 1999).

Stirling et al. (1999) reported a significant decline in the condition of both male and female adult polar bears throughout the 1980's in Western Hudson Bay, which was interrupted by improved condition in 1992 and 1993. They also found a statistically significant relationship over the 19 year study between the date of break-up and the condition of the adult female polar bears when coming ashore and natality (Stirling et al. 1999). The earlier the break-up, the poorer the condition of females coming on shore and the lower the natality level (Stirling et al. 1999). The survival of cubs from when they left their dens in early March to the following August-September when the radio-collared females and accompanying cubs were resighted also declined from 60-65% in the 1980s to just over 50% through the late 1980s and early 1990s and then increased to 70-80% through the mid-to-late 1990s (Stirling et al. 1999). The proportion of yearlings that had already been weaned in the annual capture samples fluctuated widely, but overall the maximum proportions of independent yearlings declined from about 60% in 1982 to 15-20% since 1991, but there was no statistically significant trend between the proportion of lone yearlings and the time of break-up in the same year (Stirling et al. 1999).

In two years, 1992 and 1994, radio-collared females arrived on shore later than in other years (Stirling et al. 1999). In 1992, break-up occurred three weeks later than usual, probably due to the short-term cooling effect of the eruption of Mount Pinatubo, and the arrival of 9 radio-collared animals was strongly correlated with break-up (Stirling et al. 1999). Apparently due to three weeks additional feeding time on the ice, both males and females came ashore in better condition that year (Stirling et al. 1999). In the following year, both natality and survival of cubs was significantly greater (Stirling et al. 1999). Subsequently, the condition of males and females, natality rates, and the proportion of lone yearlings in the capture sample began to decline again (Stirling et al. 1999).

Regardless of the year, the timing of break-up, or the sample size of female polar bears being tracked, the range in the mean interval after break-up that the radio-collared bears came ashore was only 21 to 28 days (Stirling et al. 1999). A major factor determining the length of the interval was that adult female bears showed strong fidelity to a particular area of the coast (Stirling et al. 1999). Examination of the last recorded positions of four females in particular indicated that fidelity to a particular area took precedence over moving further to the southeast where there was still a substantial amount of sea ice (Stirling et al. 1999).

The Western Hudson Bay population had far higher natality than any other polar bear population in the early to mid 1980s (Stirling et al. 1999). In some of those years, females successfully weaned up to approximately 40% of their cubs at 1.5 years of age, as opposed to the 2.5 years of age that is the norm in the rest of worldwide populations (Stirling et al. 1999). In the late 1980s and early 1990s, a long-term decline in both natality and condition of adult males and females was observed (Stirling et al. 1999). While these declines have not yet resulted in population declines, Stirling et al. (1999:304) cautioned that if the trends continue in the same direction, “they will eventually have a detrimental effect on the ability of the population to sustain itself.”

In summary, significant declines in the condition of polar bears in the Western Hudson Bay population as a result of global warming and the earlier break-up of the sea ice has already been documented. The earlier the date of break-up, the poorer the condition of female polar bears coming ashore to den, and the lower the natality level (Stirling et al. 1999). Cub survival also declined as the study area warmed. Impacts observed in the Western Hudson Bay population may be occurring in other populations as well, but have either not yet been recorded because other populations are not studied as intensively, or have been recorded but the results have not yet been published. As described above, global warming will continue and accelerate in this century. Global warming and the disappearance of the sea ice, if not halted, will ultimately drive polar bears to extinction. The specific mechanisms of these impacts are discussed below.

## G. Future Threats to Polar Bears from Global Warming

The polar bear is completely dependent upon Arctic sea-ice habitat for survival. Polar bears need sea ice as a platform from which to hunt their primary prey, ringed seals, to make seasonal migrations between the sea ice and their terrestrial denning areas, and for other essential behaviors such as mating. Unfortunately, the polar bear's sea-ice habitat is quite literally melting away.

According to the ACIA, "the reduction in sea ice is very likely to have devastating consequences for polar bears, ice-dependent seals, and local people for whom these animals are a primary food source" (ACIA 2004b:1). The ACIA concludes that "polar bears are unlikely to survive as a species if there is an almost complete loss of summer sea-ice cover, which is projected to occur before the end of this century by some climate models….The loss of polar bears is likely to have significant and rapid consequences for the ecosystems that they currently occupy." (ACIA 2004a:58).

In many respects, the plight of the polar bear seems quite simple and intuitive because the bears require sea ice and rising temperatures will melt that ice. However, scientists' predictions on the plight of the polar bear are more than simply intuition or mere speculation; they are based on decades of intensive research on polar bears and a large and detailed body of peer-reviewed literature. Derocher et al. (2004) recently published a comprehensive account of likely impacts to the polar bear from global warming, based on past and ongoing research. Their predictions are summarized in Table 4 and described in the sections below (Derocher et al. 2004). Overall, these scientists conclude that the "future persistence of polar bears is tenuous" (Derocher et al. 2004:172), echoing their earlier warning that "[u]ltimately, if sea ice disappeared altogether, polar bears would become extinct" (Stirling and Derocher 1993:243). The ACIA has also concluded that "polar bears are unlikely to survive as a species if there is an almost complete loss of summer sea-ice cover, which is projected to occur before the end of this century by some climate models." (ACIA 2004a:58).

**Table 4: Likely Impacts to the Polar Bear from Global Warming**
Source: Adapted from Derocher et al. (2004:171).

| **Characteristic** | **Time Frame[1]** | **Projected Change** |
|---|---|---|
| Body condition | Short | Decline, Increased variation |
| Movement patterns | Short | Alteration of existing patterns |
| Cub survival | Short | Decline, Increased variation |
| Reproductive rates | Short | Variable, Increased variation |
| Bear-human interactions | Variable | Increase |
| Den areas | Medium | Change in areas and substrates |
| Growth rates | Medium | Variable |
| Prey composition | Medium | Change in species, utilization, age of prey |
| Population boundaries | Medium | Mixing of adjacent populations |
| Population size | Medium | Variable |
| Intraspecific aggression | Variable | Increased |

| Characteristic | Time Frame[1] | Projected Change |
|---|---|---|
| Cannibalism | Variable | Possible increase |
| Adult survival | Long | Decline, Increased variation |

[1] Short = <10 years, Medium = 10-20 years, Long = >20 years. Time frame of impact will vary between populations and is dependent upon rate of change in a given population.

### *1. Shortened Seal Hunting Period*

Scientists predict that the observed decreases in adult body condition, natality, and cub survival in the Western Hudson Bay population observed to date due to earlier break-up dates and a shorter seal-hunting period will continue until female polar bears are in such poor condition that they are unable to reproduce. Using parameters including the amount of polar bear body mass lost during fasts, predicted shortening of the fasting period and lengthening of the feeding period, and the apparent 189 kg body weight needed for females to reproduce, Derocher et al. (2004) calculate that most females in the Western Hudson Bay population will be unable to successfully reproduce somewhere between 2012 and 2104.

Derocher et al. (2004) note that these calculations are simplifications, and that long-term trends may not be readily observable due to shorter-term fluctuations as global warming proceeds, but the authors predict, overall, a continuing gradual decline in population-related parameters that ultimately lead to population losses. Trends toward either earlier break-up or later freeze-up, or both, will occur in other areas in addition to Western Hudson Bay where polar bears seek seasonal refuge on land, such as Foxe Basin and south-eastern Baffin Island (Derocher et al. 2004). These populations will experience impacts comparable to those already observable in Western Hudson Bay (Derocher et al. 2004). Changes in the timing of sea-ice formation and break-up and the loss of the polar bear's sea-ice habitat will pose increasing risk to polar bears as global warming advances (Derocher et al. 2004), and ultimately all polar bear populations will suffer.

### *2. Reduced Prey Availability*

A major decline in sea-ice habitat will also likely result in a decline in polar bear abundance over time due to reduced availability of prey (Derocher et al. 2004). Ringed seals are the primary prey of the polar bear in most areas, though bearded seals, walrus, harbor seals, and beluga whales are sometimes taken and may be locally important to some populations (Derocher et al. 2004). Polar bears have been observed utilizing other food items such as blueberries, snow geese, and reindeer, but researchers do not believe that these alternate foods represent significant sources of energy (Derocher et al. 2004).

Polar bear populations are known to fluctuate based on prey availability. During the winters of 1973-1974 and 1974-1975, ringed and bearded seal numbers in the Beaufort Sea dropped by about 50% and productivity by about 90%, apparently in response to severe ice conditions (Stirling 1980; Stirling 2002). Numbers and productivity of polar bears also declined markedly in response (Stirling 1980; Stirling 2002). A similar reduction in seal productivity, with a subsequent decline in polar bear productivity, occurred in the mid-1980s as well (Stirling and Øritsland 1995; Stirling 2002).

Stirling and Øritsland (1995) calculated that a hypothetical polar bear population containing 1,800 bears would need approximately 77,400-80,293 ringed seals per year for all bears to meet their nutritive requirements. In the absence of solid data, it has generally been assumed that seal populations are large and stable and that there are enough ringed seals to fulfill the needs of both polar bears and Inuit hunters (Ferguson et al. 2005). However, one study found an unexpectedly low pregnancy rate and proportion of young-of-the-year among ringed seals in an open water sample from Arviat (Arviat's location is depicted in Figure 10) in 1991-1992 (Holst et al. 1999; Ferguson et al. 2005), and a follow up study with data from 1998-2000 also found a lower than expected pregnancy rate and proportion of young-of-the-year (Stirling 2002). These results indicate that ringed seal recruitment is likely in decline, and that ultimately ringed seal populations, and therefore food availability for polar bears, may decline as well.

A growing body of research does indeed indicate that global warming will both reduce ringed seal abundance and alter ringed seal distribution. Ice-associated seals, including the ringed seal, may be particularly vulnerable to habitat loss from changes in the extent or concentration of Arctic ice because they depend on pack-ice habitat for pupping, foraging, moulting, and resting (Tynan and DeMaster 1997; ACIA 2004a; Derocher et al. 2004). The southern edge of ringed seal ranges may also shift north, because ringed seals stay with the ice edge as it annually advances and retreats (Tynan and DeMaster 1997**)**.

Ferguson et al. (2005) demonstrated that decreasing snow depth, possibly influenced by the timing of spring break-up, may have a detrimental effect on ringed seal recruitment in Western Hudson Bay. These researchers examined trends in ringed seal recruitment in Western Hudson Bay relative to snow depth, snowfall, rainfall, temperature in April and May, North Atlantic Oscillation ("NAO") from the previous winter, and timing of spring break-up. Samples from 639 ringed seals killed by Inuit hunters between 1991-1992 and 1999-2001 were used to determine the age of all seals killed and generate a survivorship curve which represents the number of seals born in any year that survived to be included in the hunt (Ferguson et al. 2005). Percentage difference from the expected survivorship was then used as the dependent variable in correlation and regression analyses with the environmental factors (Ferguson et al. 2005). Snowfall and ringed seal recruitment varied from lower than average in the 1970s, to higher in the 1980s and lower in the 1990s (Ferguson et al. 2005).

The results of this study demonstrated that decreasing snow depth in April and May may be linked to decreased recruitment in ringed seals in Hudson Bay (Ferguson et al. 2005). Reduced snowfall may result in less snow accumulation in drifts in the lee of pressure ridges, and consequently less protection for pups from predators (Ferguson et al. 2005). Warming temperatures may also be melting the snow that covers ringed seal birth lairs and contributing to the decreased recruitment (Ferguson et al. 2005).

Ringed seal pups are born between mid-March and mid-April, nursed for about six weeks, and weaned prior to spring break-up in June (Ferguson et al. 2005). During the weeks of nursing, ringed seal pups spend about half of their time in lairs excavated in snow covering the top of the sea ice, and about half underwater diving (Ferguson et al. 2005). During this time period both ringed seal pups and adults are hunted by polar bears (Ferguson et al. 2005). One common hunting method used by polar bears is to locate a seal lair by smell, and then crash through the top of the den and seize the surprised seal (Stirling 1998). Therefore, pups in lairs with thin snow roofs are more vulnerable to predation than pups in lairs with thick roofs (Ferguson et al. 2005). Ringed seal pup survival can also be affected by hypothermia resulting from exposure if lairs collapse (Ferguson et al. 2005). Continued access to birth lairs for thermoregulation is probably critical to the survival of pups when temperatures fall below 0° C (Stirling and Smith 2004). Ferguson et al. (2005:121) conclude "Earlier spring break-up of sea ice together with snow trends suggest continued low pup survival in western Hudson Bay."

Similarly, in a study of variation in reproduction and body condition of the ringed seal in Prince Albert Sound, Harwood et al. (2000) found that an unusually early break-up in 1998 negatively impacted the growth, condition, and probably the survival of unweaned pups. The authors believe that the early breakup in 1998 led to an interruption of lactation for pups at the seaward portion of the core breeding habitat off Holman, which in turn affected the condition and growth of those unweaned pups. The authors further point out that thiis happened at a time when marine food appeared to be abundant and available for the other age classes of ringed seals (Harwood et al. 2000). The "unusually early" break-up of 1998 studied by Harwood will become the norm as climate warms. Global warming will cause the date of break-up to occur earlier each year and overall losses in extent of sea ice to continue. Global warming will therefore likely lead to significant decreases in ringed seal productivity due to interruption of ringed seal lactation and early exposure of ringed seal pups to open water conditions.

Increased rain during the late winter also impacts ringed seals by damaging or eliminating their pupping dens, increasing exposure and the risk of hypothermia and facilitating predation by polar bears and Arctic foxes (Derocher et al. 2004; Stirling and Smith 2004). In April and May of 1979, researchers documented the distribution and density of ringed seal lairs on the Hall Peninsula of southeastern Baffin Island in Nunavut (Stirling and Smith 2004). Predation on seals by polar bears was also documented, both by snow machine and helicopter (Stirling and Smith 2004). Rain fell steadily or sporadically on the study area from April 9-11, 1979 (Stirling and Smith 2004). From April 12 through April 24, the weather was clear with maximum temperatures only slightly above freezing, approximately 10-20° C warmer than normal April temperatures for the area (Stirling and Smith 2004). Before the rain event in April, there were two other periods during late March and early April when daily maximum temperatures were at or close to freezing (Stirling and Smith 2004).

The roofs of 40% (6/15) of the haul-out and birth lairs found by the end of March and 50% (15/30) of those located in the first week of April had already melted and collapsed, something not seen before at higher latitudes (Stirling and Smith 2004). After the rain event of April 9-11, 1979, 28% of the lairs in one part of the study area had collapsed, but this underestimates the real percentage because an unknown number of already washed-out lairs were not recorded (Stirling and Smith 2004). Following the rain event, the researchers noted many instances of adult seals and pups laying on the bare ice, exposing the pups to hypothermia. Predation of pups by polar bears was also observed, and the researchers "suspect that most of the pups in these areas were eventually killed by polar bears, arctic foxes, or possibly gulls" (Stirling and Smith 2004:66 (internal citations omitted)).

Stirling and Smith (2004) state that the observations from 1979 have direct relevance to the impact of climate change on polar bears:

> Should early season rain become regular and widespread at some future time, we predict that mortality of ringed seal pups will increase, especially in more southerly parts of their range, and that local populations may be significantly reduced….a significant decline in ringed seal numbers, especially in the production of young, is capable of producing negative effects on the reproduction and survival of polar bears (Smith and Stirling 2004: 66).

Ringed seals, and consequently polar bears, may also be impacted by changes in trophic dynamics. Changes in climate, sea-ice extent, and the timing of sea-ice formation and break-up will affect the lower trophic levels of the food web upon which polar bears depend (Derocher et al. 2004).

This food web is driven by the complex interactions between ice, light penetration, nutrient supply, and productivity (Tynan and DeMaster 1997**)**. Because of the Arctic Ocean's relatively low species diversity, it may be particularly vulnerable to trophic-level alterations caused by global warming (Derocher et al. 2004). Arctic cod, one of the primary prey species of ringed seals, is strongly associated with sea ice throughout its range and makes use of the underside of the ice to escape from predators (Gaston et al. 2003). It is therefore likely that a decrease in seasonal ice cover would have adverse effects on Arctic cod (Tynan and DeMaster 1997; Gaston et al. 2003).

Decreases in Arctic cod abundance have already been recorded and correlated with shrinking ice cover. Gaston et al. (2003) inferred changes in Arctic cod abundance in northern Hudson Bay by analyzing the composition of the diet fed to thick-billed murre chicks (Gaston et al. 2003). Colonial seabirds like the thick-billed murre are useful indicators of changes in marine ecosystems because the aggregation of large numbers of birds at predictable locations means that data can be obtained that integrate oceanic effects taking place over a wide area around the colony (Gaston et al. 2003). Thick-billed murre chicks are fed for 15-30 days before departing to sea with food that is carried externally in the parent's bill from the feeding grounds to the breeding colony, and therefore the food arrives undamaged and readily identifiable (Gaston et al. 2003). Gaston et al. (2003) analyzed trends in the composition of food fed to chicks in northern Hudson Bay since 1981, and compared those trends to ice cover in Hudson Bay over the same period.

Between 1980-82 and 1999, the percentage of cod in the diet of thick-billed murre chicks fell from 51.5% to 18.9%, while the percentage of capelin increased from 6.7% to 41% over the same time period (Gaston et al. 2003). Ice cover, defined as the extent of ice cover greater than 10% on July 15$^{th}$ of each year, also declined significantly between 1981 and 1999 ($F_{(1,17)} = 9.85$, $R^2 = 0.33$, $p = 0.006$) (Gaston et al. 2003). When data from 1992 (the year Mt. Pinatubo erupted and caused temporary regional cooling) were removed, the $R^2$ value increase to 0.52 ($F_{(1,16)} = 19.06$) (Gaston et al. 2003).

Gaston et al. (2003:231) concluded as follows:

> We conclude that the trends we observed related to real changes in fish populations, rather than simply reflecting changes in the accessibility of the fish to murres….Given the relative ecology of arctic cod and capelin, the trends that we have identified seem best explained by changes in the oceanography of northern Hudson Bay, perhaps driven by temperature increases over recent decades. Our evidence from the diet of nestling thick-billed murres suggests that a switch from an Arctic to a Subarctic fish community occurred from 1997 onwards.

While predicting changes in trophic dynamics from global warming is complex and difficult, the likely impact on Arctic cod is significant for the polar bear. It is possible that global warming could increase productivity of some Arctic waters in the short term (Derocher et al. 2004). As Tynan and DeMaster (1997:315) observed, "[o]ne of the central 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." At least in northern Hudson Bay, the answer to this question appears to be "no." Moreover, if areas of leads, polynyas, and open water shift northward to areas over the less productive waters of the deep polar basin as opposed to over the shallow continental shelf where they currently occur, there may not be much of an increase in productivity since the deep polar basin waters are less productive to begin with (Tynan and DeMaster 1997; Derocher et al. 2004). This could negatively impact other polar bear prey species. For example, species such as bearded seals and walrus feed on benthic prey, and are therefore found on ice cover over the shallow continental shelf areas (Derocher et al. 2004). As sea ice declines these species are forced further offshore to find suitable habitat for pupping and feeding, making activities more difficult, ultimately leading to a likely net reduction in abundance of these species (ACIA 2004a; Derocher et al. 2004).

Because ringed seal young-of-the-year provide the bulk of the polar bear diet, fluctuations in the productivity of ringed seal pups will likely be reflected immediately on polar bear reproduction and cub survival (Stirling and Lunn 1997). Stirling and Lunn (1997:176) report that "the most critical factor affecting reproductive success, subsequent condition and probably survival of polar bears is the availability of ringed seal pups from about mid-April through to break-up sometime in July," and that this is especially so for females with cubs of the year. Moreover, high levels of polar bear predation sustained by ringed seal populations are only possible because a large proportion of seals taken are young of the year (Stirling and Lunn 1997). Polar bear predation could cause ringed seal populations to crash if ringed seal recruitment declines substantially. In some areas, polar bear predation already is having a significant impact on numbers and productivity of ringed seals (Amstrup 2000).

Polar bear feeding dynamics may also lead to disproportionate impacts on immature bears. Polar bears feed preferentially on blubber and adult bears often leave much of the protein behind, which is then scavenged by younger bears who are not as highly skilled hunters (Derocher et al. 2004). The availability of adult kills to scavenge may be an important source of nutrition for these younger bears (Derocher et al. 2004). As prey availability decreases due to global warming, younger bears may be disproportionately impacted if there is less excess prey to scavenge.

Global warming will likely alter ringed seal distribution as well as ringed seal abundance (Derocher et al. 2004). A key issue will be whether prey species are accessible within the altered ice environment (Derocher et al. 2004). Increased amounts of open water may reduce the hunting efficiency of polar bears because seals may become less restrained by their need to maintain breathing holes and haul-out sites and thus become less predictable for foraging bears (Derocher et al. 2004). Bears have only rarely been reported to capture a ringed seal in open water, so it is unlikely that hunting in ice-free water would compensate for loss of ice access to ringed seals (Derocher et al. 2004). It is unlikely that increased take of bearded seals, walrus, or harbor seals, even where they are available, could or would compensate for reduced availability of ringed seals (Derocher et al. 2004). Altered prey distribution would likely lead to increased competition for prey between dominant and subordinate bears, to the detriment of the subordinates (Derocher et al. 2004).

In summary, global warming will alter the availability of polar bear prey, to the detriment of polar bears, in ways including the following:

- Reductions in sea ice, which ringed seals use for birth lairs, will alter ringed seal distribution and abundance;

- Global warming will reduce ringed seal abundance because warmer temperatures and increased rain will damage and destroy ringed seal lairs and decrease ringed seal recruitment;

- Warmer temperatures will likely alter trophic dynamics in ways that will reduce Arctic cod, one of the ringed seal's primary prey species, and therefore both reduce ringed seal abundance and change ringed seal distribution;

- Reductions in ringed seal abundance and changes in ringed seal distribution will likely have a disproportionate impact on subadult polar bears;

- As ringed seal abundance and availability decrease, polar bear populations will decline.

### 3. *Reduced Access to and Alteration of Denning Areas*

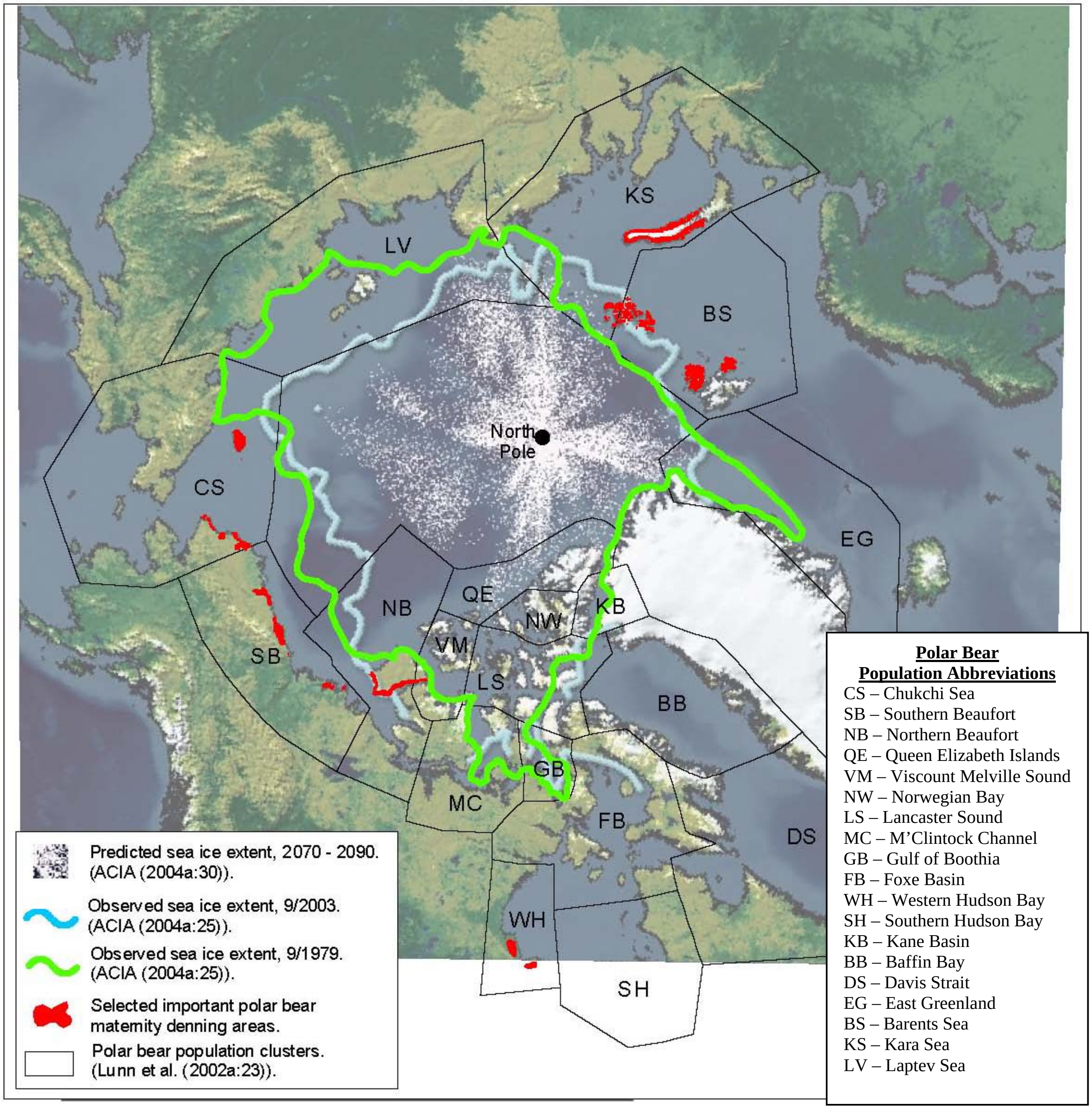
Many female polar bears return to specific den areas on land (Derocher et al. 2004). In order for a bear to reach a preferred terrestrial den site, either the ice must drift close enough or must freeze early enough in the fall for pregnant females to be able to walk or swim to the coast in time to dig a den in late October or early November (Derocher et al. 2004). As the distance increases between the southern edge of the pack ice, where some polar bear populations spend the summer, and coastal areas, where pregnant females den, it will become increasingly difficult for pregnant females to reach their presently preferred locations (Derocher et al. 2004).

Areas of concentrated polar bear denning on land include the islands of Kong Karls Land, Nordaustlandet, Edgeøya, and Barentstøya in the Svalbard Archipelago north of Norway (Larsen 1985), Franz Josef Land, Novaya Zemlya, Wrangel Island in Russia, the west coast of Hudson Bay, and the Arctic National Wildlife Refuge on the Beaufort Sea coast in the United States (Amstrup 2002). Large interannual variation in the distance between the ice and denning areas is already occurring (Derocher et al. 2004). As global warming progresses, the distance between the edge of the pack ice and land will increase (Figure 11(next page)).

Some climate models predict the complete disappearance of summer sea ice by 2100 (ACIA 2004a). One regional model predicts the complete disappearance of summer sea ice from Hudson Bay by 2050 (Gough et al. 2000). Even the five model average used by ACIA (2004a) projects enormous distances between summer sea ice and polar bear terrestrial denning sites. Moreover, the ACIA projections are based on the IPCC B2 emissions scenario and uses climate sensitivity measures that may be understated. For these reasons, actual losses of sea ice may be much greater than illustrated in Figure 11.

Under any of these scenarios, pregnant female polar bears will likely be unable to reach many of the most important denning areas in the Svalbard Archipelago, Franz Josef Land, Novaya Zemlya, Wrangel Island, Hudson Bay, and the Arctic National Wildlife Refuge and north coast of the Beaufort Sea as global warming progresses (Derocher et al. 2004; Figure 11). Scientists do not know how quickly female polar bears that previously denned on land might learn to exploit alternate denning habitat such as the drifting pack ice if they were unable to access land, or if they would respond this way at all (Derocher et al. 2004).

**Figure 11: Selected Polar Bear Terrestrial Denning Areas Compared to Past, Present, and Future Summer Sea-Ice Extent**
Source: Adapted from Lunn et al. (2002a:23) and ACIA (2004a:25, 30).




Another impact of global warming on polar bear denning will be the thinning of sea ice and likely increased drift rates of ice floes (Derocher et al. 2004). In northern Alaska, between 1981 and 1991, approximately 53% of polar bear maternity dens were found on drifting multiyear ice several hundred kilometers north of the coast (Derocher et al. 2004). While these bears appeared to successfully raise cubs, between den entry and emergence, these dens drifted between 19 and 997 km from their location when the female first entered them (Derocher et al. 2004). Increased drifting of sea ice with maternity dens could cause females with small cubs to travel longer distances and expend additional energy to return to the core of their normal home range (Derocher et al. 2004). Cubs emerging from dens in sub-optimal habitats could also experience reduced survival (Derocher et al. 2004).

In some locations, female polar bears might adopt the current denning strategy used by bears in the Western Hudson Bay population, where pregnant females leave the ice at break-up and summer in the same locations where they ultimately den (Derocher et al. 2004). This strategy requires females to accumulate sufficient fat stores to fast for up to approximately 8 months before they can return to sea ice to resume feeding on seals (Derocher et al. 2004). If the sea ice these bears were using was over the deep polar basin where seal densities are lower (as opposed to over the continental shelf), it is less likely that pregnant females would be able to meet the nutritive requirements for such a long period of fasting and nursing cubs (Derocher et al. 2004).

In addition to changes in access to or movement of denning areas, in traditional denning areas, there may be changes in the habitat available for denning (Derocher et al. 2004). For example, in Hudson Bay, pregnant females make extensive use of terrestrial dens dug into permafrost peat banks under black spruce in riparian areas (Derocher et al. 2004). Some dens may be used repeatedly (by different bears) over a period of over 200 years (Derocher et al. 2004). As temperatures warm, fire frequency will increase, and fire will destabilize the riparian banks where polar bear dens occur, making the banks unsuitable for denning (Derocher et al. 2004).

Global warming could also impact populations where females den in snow (Derocher et al. 2004). Insufficient snow would prevent den construction or result in use of poor sites where the roof could collapse (Derocher et al. 2004). Too much snow could necessitate the reconfiguration of the den by the female throughout the winter (Derocher et al. 2004). Changes in amount and timing of snowfall could also impact the thermal properties of the dens (Derocher et al. 2004). Given the highly altricial nature of polar bear cubs and their need to nurse for three months before emerging from the den, major changes in the thermal properties of dens could negatively impact cub survival (Derocher et al. 2004). Two polar bear cubs that were born unexpectedly in December, 1978 in an outdoor uninsulated cage at approximately -45° both died within 2 days (Blix and Lentfer 1979).

Finally, rain is projected to increase throughout the Arctic in winter (ACIA 2004a), and increased rain in late winter and early spring causes den collapse (Stirling and Smith 2004) and could suffocate mothers with cubs (Derocher et al. 2004). After March 1990 brought unseasonable rain south of Churchill, Manitoba, researchers observed large snow banks along creeks and rivers used for denning that had collapsed because of the weight of the wet snow, and noted that had their been maternity dens in any of these banks, it is likely that the bears would have been crushed (Stirling and Derocher 1993). With global warming, “unseasonable” rain will become increasingly commonplace.

### *4. Increased Energetic Costs of Sea-Ice Travel*

Global warming is expected to decrease the thickness of multi-year sea ice and therefore increase the rate of movement of the ice flow (Derocher et al. 2004). Polar bears tend to walk against the movement of the ice to stay in the same location, like walking the wrong way on an escalator. If ice begins to move more quickly and move further distances, bears on the sea ice may need to expend more energy to remain near preferred habitats (Derocher et al. 2004). In a parallel between the sea ice and terrestrial habitat fragmentation, it is likely that global warming will result in landscape-scale alteration of habitat connectivity for the polar bear (Derocher et al. 2004). If the width of leads increases, the transit time for bears to move across the habitat will increase due to the increased need to swim or to travel around the lead (Derocher et al. 2004). Polar bears are capable of crossing large areas of open water, but show a strong preference for sea ice (Derocher et al. 2004). Polar bears will quickly abandon sea ice for land once the sea-ice concentration drops below 50% (Derocher et al. 2004). Researchers believe this is likely due to the increased energetic costs of locomotion since moving through highly fragmented sea ice is difficult and likely more energy intensive than walking over consolidated sea ice (Derocher et al. 2004; Figure 12).

**Figure 12: Polar Bear Swimming Among Broken Ice**

Among the Floes ©Thomas D. Mangelsen/Imagesofnaturestock.com

Data on the relative energetic costs of walking and swimming are not available, but it is likely that swimming is more costly (Derocher et al. 2004). Derocher et al. (2004) suggest that as habitat patch sizes decrease, available food resources are likely to decline, resulting in reduced residency time and thus increased movement rates (Derocher et al. 2004).

As described on page 8, above, walking is relatively energy intensive for polar bears compared to other mammals, and even more so for sub-adults (Derocher et al. 2004). Therefore the relative impacts of an increased need for travel, and corresponding energy expenditures, will disproportionately impact younger animals (Derocher et al. 2004).

Another possible impact is that as movement of sea ice increases, some bears may lose contact with the main body of ice and drift into unsuitable habitat from which it may be difficult to return (Derocher et al. 2004). This already occurs in some areas such as Southwest Greenland and the island of Newfoundland (Derocher et al. 2004). Increased frequency of such events could negatively impact survival rates and contribute to population declines (Derocher et al. 2004). The earlier-than-normal break-up of ice at Hudson Bay in 1999 may have contributed to an extremely rare extralimital sighting of a polar bear at Burnett Lake in Saskatchewan at 59° 02' N, 102° 18' W (Goodyear 2003).

Space-use patterns of polar bears differ widely both among populations and between males and females within a population (Derocher et al. 2004). Because of these differences, impacts from global warming on populations will likely show a large geographic variation and may also impact males and females in different ways (Derocher et al. 2004). However, bears everywhere are likely to face some level of increased energetic costs in a warmer climate with less ice and more open water.

### *5. Demographic Effects*

Derocher et al. (2004) predict a cascade of demographic impacts on polar bear populations as a result of global warming. Polar bear characteristics including specialized diet, habitat specialization, large body size, low fecundity, long lifespan, low genetic variability, and sensitivity to events that alter adult female survival rates are all associated with high extinction risk (Derocher et al. 2004). In general, Derocher et al. (2004) predict demographic impacts that will adversely affect female reproductive rates and juvenile survival first and will only affect adult female survival rates under severe conditions.

Declines in fat reserves during critical times in the polar bear life cycle will lead to an array of impacts (Derocher et al. 2004). A decline in body condition will reduce the proportion of pregnant females that are able to initiate denning (Derocher et al. 2004). Females with lower fat stores will likely produce more single cub litters, fewer cubs overall, and smaller cubs with lower survival rates (Derocher et al. 2004). This is because body mass in adult females is correlated with cub mass at den emergence which is in turn correlated with cub survival (Derocher et al. 2004). It is likely that a higher proportion of females that do initiate denning will abandon the effort mid-winter (Derocher et al. 2004). Insufficiency of maternal resources or poor hunting conditions in the early spring after den emergence could lead to increased cub mortality (Derocher et al. 2004). For example, researchers believe that young cubs are unable to survive immersion in icy water for more than approximately 10 minutes (Blix and Lentfer 1979; Larsen 1985). This is because young cubs have little insulating fat, and polar bear fur loses its insulating value when wet (though it sheds water and recovers its insulating properties remarkably quickly), and therefore core body temperature drops rapidly in young polar bear cubs when they are immersed in icy water (Blix and Lentfer 1979). If declining sea ice forces females to swim from den areas to pack ice, cub mortality could increase due to hypothermia (Derocher et al. 2004).

Because female polar bears accrue body fat throughout their lives until approximately 15 years of age, the age of first successful reproduction could be delayed as growth rates and fat stores of females are reduced (Derocher et al. 2004). Derocher et al. (2004) also predict, overall, a lengthening of the time between successful weanings of offspring.

Derocher et al. (2004) caution that reduced reproductive rates in females may be difficult to observe, and that the decline will likely be highly variable (Derocher et al. 2004). Time lags in the system may initially obscure trends, but if conditions decline sufficiently adult survival may be impacted and sudden population declines could occur (Derocher et al. 2004). Because researchers believe mortality of polar bears is already highest in winter when fat stores are low, and because polar bears already use winter dens when necessary to conserve fat stores, Derocher et al. (2004) believe it is unlikely that the impacts described above could be compensated for with increased feeding in winter.

### *6. Increased Human Presence in the Arctic and Human-Bear Interactions*

Global warming will likely cause human populations to shift northward (AMAP 2003), increasing direct interactions between bears and humans (AMAP 2003; Derocher et al. 2004). Other consequences include increased development pressure, disturbance to bears from increased shipping activity, potentially reduced prey availability from expanded commercial fisheries, and increased risk of oil spills (AMAP 2003).

Polar bears come into conflict with humans around the edges of the polar seas and archipelagos because they will scavenge for food at sites of human habitation and also occasionally prey or attempt to prey upon humans (Stirling 1998). "Problem bears" are most often sub-adults, because these bears have the most difficulty hunting and fulfilling their nutritional requirements and because their feeding habits in the wild include a higher proportion of scavenging than adult bears (Stirling 1998). In the Northwest Territories, a preliminary study found that 82% of 44 "problem bears" killed between 1972 and 1999 were under five years of age (Lunn et al. 2002b). In the Beaufort Sea, 12 of the 16 "problem bears" killed whose ages were determined from 1973-1983 were five years of age or less, with an average age of 2.25 years (Stirling 1998). After sub-adults, females with cubs are the most likely type of bear to interact with human settlements, because females with cubs are also likely to be thinner and hungrier than single adult bears (Stirling 1998). Starving bears are particularly dangerous because they will risk death in an attempt to obtain food (Stirling 1998).

Research has also indicated that human-bear interactions, and thus the number of defense kills, increases when food availability in the wild is less available. In the eastern Beaufort Sea in the spring of 1974, seal populations were greatly reduced (Stirling 1998). Researchers predicted that subadults would be in poorer condition, interact more with humans, and suffer a higher death rate in the winter of 1974-75 (Stirling 1998). These predictions were borne out, and furthermore, once seal populations recovered, defense kills also dropped from a high of seven bears killed per winter back down to the normal two (Stirling 1998). In Churchill, researchers also noticed that in years when all bears came ashore in poorer condition, more females with cubs would come to feed at the dump in the fall when their stored fat reserves ran low (Stirling 1998). Researchers have also found that adult male polar bears, unlike adult black or brown bears, are the least likely to interact with human habitation, likely because adult male polar bears are usually in the best physical condition (Stirling 1998).

Defense kills of "problem bears" are of most concern when they are not included in an area's hunting quota, because the number of interactions and bears killed can increase quickly and cause a major impact on the population. As reviewed under "Hunting," below, most jurisdictions now include defense kills in the overall hunting quota. Scientists expect the number of interactions and defense kills to increase as global warming continues (Derocher et al. 2004). Amstrup (2000) also notes that direct interactions between people and bears in Alaska have increased markedly in recent years, and that this trend is expected to continue.

Some problems occur simply by having people in polar bear habitat, as demonstrated by the statistics from Churchill, which has the most advanced polar bear management system in the world (Table 5) (next page).

**Table 5: Manitoba Polar Bear Control Program 1997-2000**
Source: Lunn et al. (2002b:47).

| | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|
| Occurances[1] | 159 | 170 | 197 | 147 |
| Bears captured | 103 | 105 | 87 | 59 |
| Bears killed by Department personnel | 2 | 0 | 1 | 0 |
| Bears killed by public | 3 | 1 | 2 | 2 |
| Handling deaths | 3 | 0 | 2 | 1 |
| Natural deaths | 3 | 0 | 0 | 1 |
| Bears sent to zoos | 0 | 0 | 0 | 0 |

[1] All bears reported to or observed by Manitoba Conservation staff in the Churchill control zone and peripheral area

There are, however, a number of situations in which carelessness or ignorance results in the death of a polar bear (PBSG 2005). As tourism continues to increase in the Arctic, the number of these conflicts will rise (PBSG 2005). Often inexperienced people perceive a curious bear as a threat and shoot it, and, despite the fact that virtually any polar bear can kill a human at close range, often inexperienced people respond incorrectly (PBSG 2005). Poorly positioned and poorly maintained camps contribute to the problem (PBSG 2005). Recently tourists in Svalbard killed two young polar bears in separate incidents within 24 hours (PBSG 2005). One of the bears had garbage in its stomach and likely was attracted to the camp by smells of food in improperly disposed garbage (PBSG 2005).

Some tour operators have baited polar bears toward tourist vehicles so that passengers can photograph the bears close up (PBSG 2005). Juvenile polar bears have been killed by adult males when their mothers were baited toward the tourist vehicles (PBSG 2005).

Tourists and photographers can also harm bears by pursuing them with snow machines and boats for observation and photography (PBSG 2005). In one cited example, a mother was chased so long that she became separated from her cub (PBSG 2005). In Svalbard, two people chased another polar bear for an extended period of time which was videotaped and resulted in legal charges and a fine (PBSG 2005). One group of photographers followed a mother and cubs for several days that had just emerged from their den and expressed surprise that the mother did not kill a seal in this time period (PBSG 2005). The harassment likely impacted her hunting success, and lack of hunting success can mean the death of the cubs (PBSG 2005).

Finally, polar bears have been killed at cabins and remote stations where they investigate food smells (PBSG 2005). Polar bears are quick to learn that human settlements may provide food, and habituated bears are often killed when they approach settlements and camps (PBSG 2005).

In a recent study of Canadian national park visitation and human-polar bear interactions, Clark (2003) documented 52 perceived aggressive interactions[9] between people and polar bears, and one interaction that resulted in human injury. Two of the interactions resulted in bears being killed, and 87% of the interactions took place in Wapusk National Park, outside of Churchill, Manitoba, where most of the Western Hudson Bay Population comes on shore between July and November (Clark 2003). All interactions took place on land, and all occurred during summer or fall (Clark 2003). In Wapusk National park the number of interactions appeared to increase in years with earlier on-shore dates, as did

[9] Clark (2003) chose the term "perceived aggressive interaction" to make the important point that not all polar bear interactions perceived as aggressive by humans are the result of polar bears that are in fact aggressive, as many such bears may simply be inquisitive.

the number of bears captured in and around Churchill, but due to small sample size the relationships were not statistically significant (Clark 2003).

Clark (2003) found no relationship between the rates of interaction and park visitation, suggesting that sea-ice availability and the amount of time the bears are forced on land may be a more important variable in the rate of interactions than park visitation itself. Overall, the results of Clark (2003) were consistent with Derocher et al.'s (2004) hypothesis that longer ice-free periods increase the number of polar bear-human interactions.

Clark (2003) found that bears were reported killed in only 4% of the perceived aggressive interactions, which was much less than the 61% reported by a previous study. Possible explanations include the fact that Clark's (2003) study was confined to interactions in national parks, where visitors are not encouraged to carry firearms and are educated on bear safety, and the fact that a high proportion of the interactions took place near two research camps that have operated for over 30 years and have formalized bear response procedures including non-lethal deterrent measures (Clark 2003).

Bear sitings near camps were also much more likely to lead to perceived aggressive interactions than bear sitings away from camps (Clark 2003). This could be due to a number of factors, including the fact that attractants such as food motivate bears into encounters with people, and the fact that people may perceive bears as more aggressive near a camp than far from it (Clark 2003).

Increased human activity in the Arctic will lead to other impacts to polar bears as well. The disappearance of sea ice from many waters for much of the year will encourage shipping, tourism, oil exploration and other industrial activities (AMAP 2003).

Russian scientists cite increasing use of a Northern Sea Route for transit and regional development as a major source of disturbance in the Russian Arctic (Belikov and Boltunov 1998). The Northern Sea Route is the name for the seasonally ice-covered marine shipping routes across the north of Eurasia from Novaya Zemlya in the west to the Bering Strait in the east (ACIA 2004a). The Northern Sea Route is administered by the Russian Ministry of Transport and has been open to marine traffic of all nations since 1991(ACIA 2004a). For trans-Arctic voyages, the Northern Sea Route represents up to a 40% savings in distance from northern Europe to northeastern Asia and the northwest coast of North America compared to southerly routes via the Suez or Panama Canals (ACIA 2004a). Commercial navigation on the Northern Sea Route could disturb polar bear feeding and other behaviors and would increase the risk of oil spills (Belikov et al. 2002).

Regional as well as trans-Arctic shipping along the Northern Sea Route is very likely to benefit from a continuing reduction in sea ice, which poses major challenges and requires specially reinforced ships as well as ice-breakers (ACIA 2004a). The further north the ice edge retreats, the further north ships can sail in open water on trans-Arctic voyages, thereby avoiding the shallow shelf waters (which require ships of shallow draft, thereby reducing the amount of cargo that may be carried and profitability) and narrow straits of the Russian Arctic (ACIA 2004a). Ships involved in expanded use of the Northern Sea Route would likely use leads and polynyas to avoid breaking ice and reduce transit time (FWS 1995). Leads and polynas are essential habitat for polar bears, especially in winter and spring, and heavy shipping traffic could disturb the bears during critical times (FWS 1995).

Increased shipping will also greatly increase the risk of an oil spill (FWS 1995). The threats posed to polar bears by oil are discussed in Appendix B.

Commercial fisheries are also expected to expand into Arctic waters (AMAP 2003). Expanded commercial fisheries could alter the food web structure in the oceans (AMAP 2003), further reducing prey availability for ringed seals and polar bears in turn.

### *7. Conclusion*

Worldwide, habitat loss is the primary cause of species extinction (Primack 2001). The polar bear is threatened with extinction because its sea-ice habitat is already literally melting away due to global warming, and because global warming is projected to accelerate in this century.

Impacts to polar bears and the mechanisms of extinction are being rigorously documented, and the data published in peer-reviewed journals. The best available science is unequivocal that polar bears will decline in condition and abundance, and ultimately become extinct if global warming is not substantially slowed. As the Polar Bear Specialist Group, the pre-eminent scientific body for the study of the polar bear, summarizes on their website, "[t]here is little doubt that polar bears and other ice-inhabiting marine mammals in the Arctic, are being, or will be, negatively affected by the effects of climate change via changes to their habitats" (PBSG 2005). Warnings regarding the negative impacts of global warming are mounting on many fronts. As one recent report noted "If current trends continue, polar bears and other species that require a stable ice platform for survival could become extinct by the end of the century" (Rosentrater 2005:3).

## H. Regulatory Mechanisms are Inadequate to Protect Polar Bears From Global Warming

Global warming is the primary threat to the polar bear, and also the most difficult threat to regulate. The primary international regulatory mechanisms addressing global warming are the United Nations Framework Convention on Climate Change and the Kyoto Protocol. While the entering into force of the Kyoto Protocol on February 16, 2005 marks a significant partial step towards the regulation of greenhouse gases, it does not and cannot adequately address the impacts of global warming that threaten the polar bear with extinction. There are currently no legal mechanisms regulating greenhouse gases on a national level in the United States. As detailed below, all existing regulatory mechanisms are clearly inadequate to protect the polar bear from likely extinction. Tragically, past regulatory successes, such as the control of overhunting in the 1950s and 1960s, will be rendered meaningless if global warming continues.

### *1. The United Nations Framework Convention on Climate Change*

The United Nations Framework Convention on Climate Change ("UNFCCC") was adopted in May 1992 at the first Earth Summit held in Rio de Janeiro, Brazil, and entered into force in March 1994 (EIA 2004). The stated objective of the UNFCCC is the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system (EIA 2004). Due to the complexity of climate issues and the widely divergent political positions of the world's nation states, the UNFCCC itself was unable to set emissions targets or limitations, but instead created a framework that set the stage for a range of subsequent actions (UNFCCC 2004). The UNFCCC covers greenhouse gases not otherwise controlled by the Montreal Protocol on ozone-depleting substances (UNFCCC 2004).

The UNFCCC assigns differing responsibilities to its 189 parties, based on their differing levels of economic development (UNFCCC 2004). Annex I parties include 41 mostly developed countries. Annex I countries set a goal (but not a requirement) of returning their emissions by 2000 to 1990 levels (UNFCCC 2004). They are required to make regular reports on implementation, including reporting on levels of greenhouse gas emissions and policies and measures to reduce them (UNFCCC 2004). Annex II is a subset of Annex I countries which includes the 23 highly developed countries which are required to financially and otherwise support the efforts of the developing countries (UNFCCC 2004). Countries with economies in transition ("EITs") include 14 countries in Eastern and Central Europe and the former Soviet Union which are listed in Annex I but do not have the additional responsibilities of the other Annex I countries. Non-Annex I parties include all parties not included in one of the former categories, and are mostly developing countries (UNFCCC 2004). Non-Annex I parties have general commitments to respond to climate change but have fewer obligations and are expected to rely upon external support.

The UNFCCC has not effectively controlled greenhouse gas emissions. The year 2000 has come and gone without the UNFCCC's goal of reducing greenhouse gas emissions from Annex I countries to 1990 levels being met. More than ten years after the UNFCCC came into force, "dangerous anthropogenic interference with the climate system" remains undefined (International Climate Change Taskforce 2005). There is a growing body of evidence, however, that anthropogenic greenhouse gas emissions have already caused "dangerous" climate change.

Unusually high temperatures in the summer of 2003 caused human death rates to spike, especially among the elderly, in several European nations (Stott et al. 2004). Scientists have established that past human influence has more than doubled the risk of European mean summer temperatures as hot as those in 2003 (Stott et al. 2004). Moreover, according to one projection of future greenhouse gas emissions levels (the IPCC SRES A2 emissions scenario, discussed below), more than half of years will be warmer than 2003 by the year 2040, and by the end of this century, 2003 would be classed as an anomalously cold summer relative to the new climate (Stott et al. 2004).

Recently, one report has proposed that global warming must be limited to 2° C above pre-industrial temperatures in order to avoid dangerous climate change (International Climate Change Taskforce 2005). Under current conditions, this level will be reached sometime between 2026 and 2060 (New 2005). It is still difficult to specify the exact atmospheric concentration of carbon dioxide that corresponds to a given temperature increase. Nevertheless, the best available information indicates that achieving a high probability of limiting global average temperature rise to 2° C will require that that net warming influences on the global climate by the year 2100 be no greater than what would be associated with atmospheric carbon dioxide concentrations of no more than 400 ppm (International Climate Change Taskforce 2005). The atmospheric carbon dioxide concentration is already 380 ppm (compared to a pre-industrial concentration of 280 ppm) and rising at more than 2 ppm annually (International Climate Change Taskforce 2005). Large and rapid cuts in greenhouse gas emissions are needed in order to prevent carbon dioxide concentrations from rising above 400 ppm. These cuts are extraordinarily unlikely to occur within the current regulatory framework. Moreover, even if global average temperature increases were limited to 2° C, this would still translate into much greater temperature increases in the Arctic, of 3.2°-6.6° C, which will be greatest in winter (4°-10° C) and less in summer (1.5°-3.5° C) (New 2005), as well as massive reductions in sea ice.

In sum, even if average global temperature increases were limited to 2° C, which is extremely unlikely without new regulation and technology, this would likely be too little, too late, to save polar bears from extinction. Scientists have already stated "it is difficult to avoid the conclusion that potentially dangerous anthropogenic interference in the climate system is already underway" (Stott et al. 2004:613), and that there simply is no "safe" level of elevated carbon dioxide concentrations (Stainford et al. 2005).

### *2. The Kyoto Protocol*

In 1997 the Kyoto Protocol became the first additional agreement added to the UNFCCC to set emissions targets. The Kyoto Protocol set goals for developed countries only to reduce their emissions to at least 5% below their 1990 levels (UNFCCC 2004). The Kyoto Protocol required ratification by a minimum of 55 countries, encompassing at least 55% of the carbon dioxide emissions of Annex I countries before it would enter into force. Over seven years passed before this occurred. The Kyoto Protocol entered into force on February 16, 2005, 90 days after it was ratified by Russia (UNFCCC 2005).

Despite its long-awaited ratification, the Kyoto Protocol is inadequate to prevent significant climate change, and consequently the likely extinction of the polar bear. First, the Protocol's overall emissions targets are highly unlikely to be met, due in large part to the refusal of the United States to ratify the agreement. Second, even if the Kyoto targets were met, they are far too modest to impact greenhouse gas concentrations and global warming sufficiently to ensure the survival of the polar bear. Each of these issues is addressed in turn below.

The refusal of the United States to ratify the Kyoto Protocol, announced by the Bush Administration in 2001, is a major reason why Kyoto targets are unlikely to be met. Because the United States is responsible for approximately <u>24% of worldwide carbon dioxide emissions</u> (EIA 2004), it is highly unlikely that overall targets can be met without US participation. The Kyoto target for the US was a 7% reduction in greenhouse gas emissions levels from 1990 levels by 2012 (EIA 2004). Between 1990 and 2001, United States emissions have in fact <u>increased</u> by 13%. Total United States emissions are projected to grow a staggering additional <u>43.5% through the period 2025</u> (GAO 2003a).

In addition to the outright intransigence of the United States, the overall and many country-specific Kyoto targets are unlikely to be met based on current progress and data. While some Annex I countries have achieved their Kyoto targets or at least some reductions, many other Annex I countries have seen their emissions increase substantially (Figure 13 (next page)). Emissions also increased in many of the developing nations between 1990 and 2000 (UNFCCC 2004). In addition, although emissions of the EIT countries decreased significantly from 1990-2000 as a result of economic contraction in these countries, they increased from 2000 to 2001 and are projected to continue to do so (EIA 2004). Overall, the EIA estimates that worldwide carbon emissions in 2025 will exceed 1990 levels by 72% (EIA 2004).[10]

[10] EIA 2004 projections do not reflect the potential impacts of the Kyoto treaty, because it had not yet come into force when the projections were prepared (EIA 2004). Compliance with Kyoto or other measures to reduce greenhouse gases could cause actual emissions to differ from the projections (EIA 2004), however, as discussed above, compliance with overall Kyoto targets is unlikely.

**Figure 13: Changes in Greenhouse Gas Emissions by Annex I Countries, 1990-2001**
Source: UNFCC (2004:25).


There are other problems with implementation of the Kyoto Protocol as well. For example, accurate, consistent, and internationally comparable information that is essential for sound policymaking is still lacking in many areas (UNFCCC 2004). Many countries have yet to build a sound institutional framework and a number have yet to even report on their institutional arrangements or have pointed out that their systems are weak (UNFCCC 2004). The Protocol will only succeed at meeting its modest goals if the parties fulfill their commitments, yet mechanisms for enforcement have not yet been tested and are likely ineffective. There are no financial penalties or automatic consequences for failing to meet Kyoto targets (UNFCCC 2004).

Even in the unlikely event that overall Kyoto targets were fully met by the year 2012, the reductions are far too small to substantially reduce global warming and improve the plight of the polar bear. Implementation of the Kyoto Protocol would only slightly reduce the rate of growth of emissions – it would not stabilize them (Williams 2002). Carbon dioxide levels currently stand at 380 ppm, from pre-industrial levels of 280 ppm, and are increasing at more than 2 ppm per year (International Climate Change Taskforce 2005). Stabilizing carbon dioxide concentrations at 440 ppm (23% above current levels, and a level likely to lead to a greater than 2° C average global temperature rise) would require global emissions to drop below 1990 levels within a few decades, with emissions eventually declining to a very small fraction of current levels, despite growing populations and an expanding world economy. These cuts will not be achieved simply by compliance with Kyoto (Williams 2002). The IPCC SRES scenarios predict carbon dioxide concentrations of between 490 and 1260 ppm by 2100 (Albritton et 2001), and these scenarios all assume significant reductions in the rate of greenhouse gas emissions (Nakićenović et al. 2000).

Additionally, Kyoto only sets targets for action by 2012. There is no current regulatory mechanism governing greenhouse gas emissions in the years beyond 2012. Discussions for targets for the second compliance period from 2012-2016 have not yet begun (EIA 2004). While the European Union delegation attempted to begin discussions at the Conference of the Parties in Milan, Italy in 2003, and in Buenos Aires in 2004, progress was blocked by other nations, including the United States (EIA

2004). A meeting to discuss parameters of future discussions is set for Bonn in May, 2005. But again, no binding or even voluntary agreement yet exists to deal with the cuts needed beyond the Kyoto Protocol.

Because the climate responds to changes in greenhouse gas concentrations with a time lag, past emissions have already committed the planet to a certain degree of warming and climate change (IPCC 2001a; Williams 2002; ACIA 2004a). After greenhouse gas concentrations have stabilized, global average surface temperatures will continue to rise at a rate of a few tenths of a degree per century (IPCC 2001a). Ice sheets will continue to react to climate warming for thousands of years after greenhouse gas levels have been stabilized (IPCC 2001a).

Finally, while new technology in the areas of energy efficiency, alternative energy sources, and carbon sequestration is expected to emerge (UNFCCC 2004), it appears unlikely to do so sufficiently quickly to affect global warming in the Arctic and thereby ensure the survival of polar bears. The International Institute for Applied Systems Analysis suggests that it takes between 50 and 100 years for a new energy resource and its associated technology to increase its market share from 1% to 50% (UNFCCC 2004). Polar bears and their sea-ice habitat do not have the luxury of waiting until new uncertain technologies come on line.

The goal of the UNFCCC is to stabilize greenhouse gas concentrations in the atmosphere at a level that prevents dangerous anthropogenic interference with the climate system (EIA 2004). Yet scientists have already stated "it is difficult to avoid the conclusion that potentially dangerous anthropogenic interference in the climate system is already underway" (Stott et al. 2004:613) (discussing the contribution of past greenhouse gas emissions to the deadly European heatwave of 2003), and that there simply is no "safe" level of elevated carbon dioxide concentrations (Stainford et al. 2005).

### *3. United States Climate Initiatives are Ineffective*

Because the United States is responsible for approximately 24% of worldwide carbon dioxide emissions, regulation of United States greenhouse gas emissions is essential to saving polar bears from extinction. Unfortunately, despite the nature and magnitude of the risks, and a variety of actions by Congress and the Executive Branch, there is still no regulation of greenhouse gas emissions on the national level in the United States.

Beginning in 1978, Congress established a "national climate program" to improve understanding of global climate change through research, data collection, assessments, information dissemination, and international cooperation. National Climate Program Act of 1978, 15 U.S.C. §§ 2901 *et seq.* Two years later, in the Energy Security Act, Congress directed the Office of Science and Technology Policy to engage the National Academy of Sciences in a study of the "projected impact, on the level of carbon dioxide in the atmosphere, of fossil fuel combustion, coal-conversion and related synthetic fuels activities" authorized by the Energy Security Act. Pub. L. No. 96-294, tit. VII, § 711, 94 Stat. 611, 774-75 (1980). In 1990, Congress enacted the Global Change Research Act, 15 U.S.C. §§ 2931-2938, which established a 10-year research program for global climate issues, directed the President to establish a research program to improve understanding of global change, and provided for scientific assessments every four years that analyze current trends in global change. *Id.* at §§ 2932, 2933, 2936(3). Congress also established a program to research agricultural issues related to global climate change. Pub. L. No. 101-24, tit. XXIV, § 2402, 104 Stat. 4058, 4058-59 (1990). Finally, two years later, in the Energy

Policy Act of 1992, Congress directed the Secretary of Energy to conduct several assessments related to greenhouse gases and report to Congress. Pub. L. No. 102-486, § 1604, 106 Stat. 2776, 3002.

The Global Climate Protection Act of 1987 directed the Secretary of State to coordinate U.S. negotiations concerning global climate change. 15 U.S.C. § 2901 note; § 2952(a). Following those negotiations, President George H.W. Bush signed, and the Senate approved, the UNFCCC, which, as discussed above, has yet to effectively control greenhouse gas emissions.

The United States Clean Air Act ("CAA") also fails to regulate carbon dioxide emissions, focusing instead on research and monitoring. Section 103(g) directs the Environmental Protection Agency ("EPA") to establish a "basic engineering research and technology program to develop, evaluate, and demonstrate nonregulatory strategies and technologies for air pollution prevention" that would address substances including carbon dioxide. 42 U.S.C. § 7403(g). The CAA also states that nothing in Section 103(g) "shall be construed to authorize the imposition on any person of air pollution control requirements." *Id.*

In 2003, the EPA rejected a petition urging it to regulate greenhouse gas emissions from automobiles, stating as follows:

> After careful consideration of petitioners' arguments and the public comments, EPA concludes that it cannot and should not regulate [greenhouse gas] emissions from U.S. motor vehicles under the CAA. Based on a thorough review of the CAA, its legislative history, other congressional action and Supreme Court precedent, EPA believes that the CAA does not authorize regulation to address global climate change. Moreover, even if [carbon dioxide] were an air pollutant generally subject to regulation under the CAA, Congress has not authorized the Agency to regulate [carbon dioxide] emissions from motor vehicles to the extent such standards would effectively regulate car and light truck fuel economy, which is governed by a comprehensive statute administered by DOT.
>
> In any event, EPA believes that setting [greenhouse gas] emission standards for motor vehicles is not appropriate at this time. President Bush has established a comprehensive global climate change policy designed to (1) answer questions about the causes, extent, timing and effects of global climate change that are critical to the formulation of an effective, efficient long-term policy, (2) encourage the development of advanced technologies that will enable dramatic reductions in [greenhouse gas] emissions, if needed, in the future, and (3) take sensible steps in the interim to reduce the risk of global climate change. The international nature of global climate change also has implications for foreign policy, which the President directs. In view of EPA's lack of CAA regulatory authority to address global climate change, DOT's authority to regulate fuel economy, the President's policy, and the potential foreign policy implications, EPA declines the petitioners' request to regulate [greenhouse gas] emissions from motor vehicles. 68 Fed. Reg. 52922, 52925 (footnote omitted).

The George W. Bush Administration's climate initiative referenced in the EPA notice above, and revealed after the Administration renounced the Kyoto Protocol, plainly fails to effectively address global warming. This initiative is based entirely on voluntary measures which are incapable of effectively controlling greenhouse gas emissions. This climate plan, termed the Global Climate Change Initiative, also focuses only on reducing the amount of greenhouse gas emissions per unit of energy produced ("emissions intensity"), not the overall level of emissions (GAO 2003a). In the absence of new climate initiatives, United States emissions intensity is expected to decrease by 14% by 2012, while total emissions continue to increase (GAO 2003a). The Bush plan, if fully implemented and successful, would decrease emissions intensity by a mere additional 4%, for an overall reduction of 18%, but total emissions would still continue to increase. Even according to the Bush Administration's own arithmetic, full implementation and success of the plan will result in US greenhouse gas emissions in 2012 that are 30% higher than 1990 emissions, as opposed to the 7% reduction called for by the Kyoto Protocol (Holdren 2003). Cumulative emissions between 2002-2012 will continue to grow and would be a mere 2% less with the plan than without it (GAO 2003a).

Moreover, the US Government Accounting Office ("GAO") found that the Bush plan does not explain how even the modest 4% claimed reduction in energy intensity will be met. The Bush plan fails to provide any emissions savings estimates at all for 19 of the 30 plan elements (GAO 2003b). Of those 19, at least two seem unlikely to yield any emissions savings at all by 2012 (GAO 2003b). Of 11 initiatives for which savings estimates were provided, at least eight were not clearly attributable to the Bush plan, and there were problems with others as well (GAO 2003b). Overall, the GAO could confirm that emissions savings would be realized from only three of the Bush plan elements (GAO 2003b), an extremely inauspicious finding for the ultimate success (and the good faith intentions) of the already modest proposal.

For all the reasons discussed above, existing regulatory mechanisms relating to global warming are inadequate to ensure the continued survival of the polar bear. Global warming is well underway, and ensuring the polar bear's survival requires immediate and dramatic action to reduce greenhouse gas emissions, particularly in the United States. Protecting the polar bear under the Endangered Species Act will bring attention to its plight and encourage both voluntary and regulatory action.

## III. OTHER FACTORS THREATENING POLAR BEARS

### A. Oil and Gas Exploration and Development

Oil and gas activities currently pose a threat to several polar bear populations. The threats from oil and gas exploration and development are increasing as development continues to expand throughout the United States Arctic and internationally. Oil and gas exploration and development in the Arctic can impact polar bears in a number of ways including the following: (1) damage or destruction of essential habitat; (2) contact with and ingestion of oil from acute and chronic oil spills; (3) contact with and ingestion of other contaminants; (4) attraction to or disturbance by industrial noise and harassment by aircraft, ships, and other vehicles; (5) death, injury, or harassment resulting from interactions with humans; (6) increased hunting pressures; and (7) potential mortality, injury, and stress resulting from handling and interaction designed to evaluate and/or investigate all of the above (Lentfer 1990).

Oil and gas exploration and development activities have been most extensive in the US Arctic, and proposals to open the currently protected United States Arctic National Wildlife Refuge, which contains the highest concentration of polar bear maternity dens in Alaska, as well as extensive offshore leasing in the Beaufort Sea poses a significant threat to the Southern Beaufort Sea population. Despite the fact that oil and gas development is not yet as extensive in polar bear habitat in Canadian, Norwegian, Russian and Greenland territory, it still poses a threat to many polar bear populations. In Canada, development of oil and gas leases in the Mackenzie River Delta and in the Beaufort Sea would extend oil and gas development along virtually the entire Beaufort Sea Coast occupied by the Southern

Beaufort Sea polar bear population. Scientists call oil and gas development in the Norwegian and Russian Arctic a "threat to polar bear habitat for many reasons" (Derocher et al. 2002).

Appendix B summarizes the level of past, current, and future projected oil and gas development by country, and discusses each of the threats posed to polar bears by such activity in detail.

### B. Hunting

The genesis of international polar bear conservation efforts was the response to severe over hunting of some polar bear populations in the 1950s and 1960s. The response of the international scientific and management community to successfully control this overhunting is widely regarded as one of the great wildlife management success stories. Scientific bodies such as the PBSG, which plays a central role in international conservation of the polar bear and calculation of harvest limits today, had their origins during this time. Today there is extensive regulation and monitoring of polar bear hunting. For example, polar bear hunting by Alaska Natives is considered sustainable and well managed. Despite these important past successes, however, overhunting, including illegal poaching, currently poses a threat to as many as half of all polar bear populations.

The PBSG meets every three to five years and reviews current data on all aspects of polar bear science and management. The PBSG most recently published worldwide polar bear harvest statistics and estimates of sustainable harvest in 2001 (Lunn et al. 2002a). As of 2001, most polar bear populations were harvested below, at, or near sustainable levels (Lunn et al. 2002a), though overharvest was apparent in the M'Clintock Channel population and Gulf of Boothia population, and strongly suspected in the Chukchi Sea Population. In January, 2005 the Government of Nunavut announced an increase in overall harvest quota for Nunavut, where a large percentage of the world's polar bear hunting takes place, from 403 to 518 polar bears, an increase of 115 bears, or over 28% (Government of Nunavut 2005). If Nunavut hunters kill all or most of the bears allocated by the overall quota, an additional seven polar bear populations may be harvested at levels exceeding the sustainable harvest as determined by the PBSG in 2001. Polar bears threatened by ongoing or potential overharvest now include Chukchi Sea, M'Clintock Channel, Gulf of Boothia, Viscount Melville Sound, Lancaster Sound, Foxe Basin, Western Hudson Bay, Southern Hudson Bay, Kane Basin, and Baffin Bay populations.

The threat from potential overhunting is of particular concern because the impacts of global warming will exacerbate the impact of any unsustainable harvest. Global warming's impact on adult body condition and reproductive rates has already been documented in the Western Hudson Bay population and these impacts will be replicated in other populations (to the degree they are not already occurring but undocumented) as global warming progresses. Global warming will lead to changes in survival rates, age of maturity, and reproductive rates. Changes in these factors can in turn change sustainable harvest levels (Derocher et al. 2004). Despite the fact that population modeling and calculation of sustainable harvest in polar bear populations have evolved rapidly and are constantly refined by experts, new inventory methods may be needed to address amplified impacts from hunting and global warming (Derocher et al. 2004).

Despite past regulatory success stories, currently one half of all polar bear populations globally are threatened by potential overharvest. This is troubling because hunting of polar bears should be managed more conservatively due to the current and future impacts of global warming. Populations that are not currently overharvested may become so in the near future when global warming affects parameters such as survival and reproductive rates that determine sustainable harvest rates.

Additional information on the regulation and status of polar bear harvest in each of the five polar bear nations is summarized in Appendix C.

## C. Contaminants

Polar bears, as the apical Arctic predator, carry extremely high levels of persistent organic pollutants ("POPs") and other contaminants. These contaminants are primarily transported to the Arctic from distant sources, and both biomagnify and bioaccumulate in polar bears. There is a growing body of evidence that POPs such as PCBs are adversely impacting polar bears' immune system, thyroid systems, and reproduction. Global warming will interact with pollution transport and accumulation in diverse ways which may exacerbate impacts to polar bears. Threats to the polar bear from POPs and other contaminants are reviewed in detail in Appendix D.

## E. Disease

Polar bears suffer from relatively few diseases and parasites due to their use of a marine system and diet made up mostly of fat in which few parasites reside (Derocher et al. 2004). Polar bears do carry *Trichinella* sp., but the incidence of reported disease is low (Derocher et al. 2004). While *Trichinella* sp. concentrations in polar bear tissue can be high, the infections are normally not fatal (Amstrup 2003). Several polar bears have also been infected with brucellosis, a bacterial infection that can be lethal even when the immune response is fully operational (Norwegian Polar Institute 2003). One incidence of rabies has been confirmed in a polar bear, which could have been contracted from an Arctic fox, an animal that is a common rabies carrier (Amstrup 2003). The relative lack of parasites and disease exposure apparent in polar bears could make them more vulnerable to new pathogens (Derocher et al. 2004).

Contaminant levels in the Arctic already impact the endocrine system, reproductive system, and immune system of polar bears, making them more vulnerable to disease (Derocher et al. 2004). Global warming will also likely alter the pathways and processes by which contaminants enter the Arctic, possibly amplifying this impact (Derocher et al. 2004). Nutritional stress could also cause further suppression of the polar bear immune system (Derocher et al. 2004). It is also possible that new parasites and diseases could expand their range northward as the Arctic climate warms (Derocher et al. 2004). Some researchers believe that a warming climate could increase diseases that cause mass mortalities of seals (FWS 1995).

Disease, therefore, does not appear to be an imminent threat to the survival of the polar bear, but could emerge as a much more serious threat in the foreseeable future.

## F. Predation

In rare instances, polar bears will kill and eat other polar bears (Stirling 1998). The most common scenario is a large male taking either a cub or a mother attempting to defend her cub (Stirling 1998). There is no evidence that these instances pose a threat to the continued survival of the species.

Stirling (1998) reports a single instance of a wolf pack learning to prey on polar bear cubs traveling from their maternity dens to the sea ice south of Churchill on Hudson Bay, but there is no evidence that predation by wolves is at all widespread or poses a threat to the continued survival of the species.

Hunting by humans is discussed above and in Appendix C.

## G. Scientific Research and Collecting

Except for the limited exception noted above under "Oil and Gas Development," scientific research has been and remains essential to conserving the polar bear. There is no indication that scientific research poses any threat to the polar bear. To the contrary, resources for polar bear research should be increased to the maximum extent possible because polar bears are increasingly threatened by global warming, contaminants, and the other factors discussed herein, and additional monitoring of polar bear populations is critical to determining appropriate management actions.

## H. Existing Regulatory Mechanisms are Inadequate to Protect Polar Bears

Regulatory mechanisms worldwide are inadequate to protect polar bears from the threats discussed in this section. Appendix E provides a detailed account of applicable national and international law and their role and limitations relative to threats to polar bears.

## The FWS Must Designate Critical Habitat for the Polar Bear

The FWS must designate critical habitat for the polar bear concurrently with its listing under the ESA. Critical habitat is defined by Section 3 of the ESA as:

> (i) the specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of section 1533 of this title, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and
>
> (ii) specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 1533 of this title, upon a determination by the Secretary that such areas are essential for the conservation of the species.

16 U.S.C. §1532(5).

The designation and protection of critical habitat is one of the primary ways in which the fundamental purpose of the ESA, "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved," including providing for the <u>recovery</u> of species, is achieved. One of the primary benefits critical habitat affords listed species is through additional protections under Section 7 of the ESA. 16 U.S.C. §1536(a)(2). The Section 7 consultation requirements provide that no action authorized, funded, or carried out by any federal agency will "jeopardize the continued existence of any endangered species or threatened species *or result in the destruction or adverse modification of [critical habitat]*." 16 U.S.C. §1536(a)(2)(emphasis added). While the FWS has previously defined "destruction or adverse modification" as an "alteration that appreciably diminishes the value of critical habitat for both the survival and recovery of a listed species" (50 C.F.R. §402.02), this definition has been repeatedly invalidated by the judiciary in response to litigation brought by conservation organizations including Petitioner Center for Biological Diversity.

Between 1998 and 2004, at least eight courts (including three different Circuit Courts of Appeals) judged FWS's adverse modification regulation illegal. Two struck it down. None upheld it. In the most recent appeals court decision, the Ninth Circuit stated: "This can not be right. If the [FWS] follows its own regulation, then it is obligated to be indifferent to, if not to ignore, the recovery goal of critical habitat." <u>Gifford Pinchot Task Force v. United States Fish and Wildlife Service</u>, 378 F.3d 1059 (9th Cir. 2004). As one federal court succinctly stated: "critical habitat is the area 'essential' for 'conservation' of listed species….Conservation means more than survival; it means recovery…(T)he proper definition of 'destruction or adverse modification' is: 'a direct or indirect alteration of critical habitat which appreciably diminishes the value of that habitat for *either* the survival *or* the recovery of a listed species" <u>Center for Biological Diversity et al. v. Bureau of Land Management et al.</u>, CV 03-02509 SI (emphasis added).

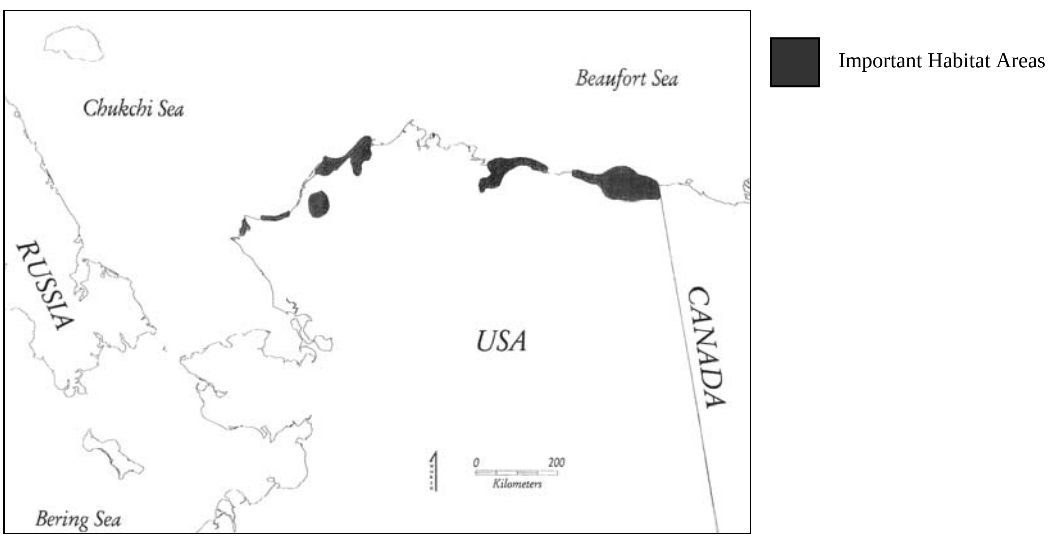
Conservation groups have also brought litigation that has increased the rate of critical habitat designation. Rather than celebrate the revival of the moribund program, the FWS has opposed every designation and has drafted a lengthy "disclaimer" that appears in every critical habitat proposal, designation and press release. The disclaimer states that critical habitat is wholly redundant to other protections and that "in 30 years of implementing the ESA, the [Fish and Wildlife] Service has found that the designation of statutory critical habitat provides little additional protection to most listed species..." See, e.g., 69 Fed. Reg. 48570, 48571. Yet the FWS has admitted it has absolutely no evidence to support this claim (Suckling and Taylor in press).

To the contrary, Suckling and Taylor (in press) show that multiple statistical analyses have demonstrated that species with critical habitat are recovering faster than those without it. The analysis based on the largest dataset and longest time horizon found that species with critical habitat were more than twice as likely to be recovering as those without it (Suckling and Taylor in press). Moving beyond correlation and to an understanding of the mechanisms through which critical habitat benefits species, these authors present numerous case studies showing that critical habitat works through a great variety of regulatory and non-regulatory avenues (Suckling and Taylor in press). Some are driven by federal agencies, some by counties, and others by private land owners, and all demonstrate that critical habitat is a broad conservation planning tool that provides great benefits to listed species (Suckling and Taylor in press).

For all the foregoing reasons, Petitioner requests that the FWS propose critical habitat for the polar bear concurrently with its proposed listing as threatened as required by the Endangered Species Act.

The FWS has already designated Important Habitat Areas for polar bears within United States Jurisdiction (FWS 1995; Figure 14). At a minimum, polar bear critical habitat must include these Important Habitat Areas. Other essential polar bear habitat is described below. Petitioner will submit additional comments regarding critical habitat once the FWS has issued a positive 90-day finding on this Petition and initiated a status review.

**Figure 14: FWS Designated Important Habitat Areas for Polar Bears**
Source: FWS(1995:68).




Sea ice is essential habitat for polar bears. Key polar bear feeding areas are adjacent to leads and polynyas (Lentfer 1990; FWS 1995). Some major leads and polynas occur in the same place each year, while in other areas the occurrence of leads and polynas varies considerably between years. Both types are essential for polar bears. Predicatable leads and polynyas have been identified along the annual ice adjacent to the continental Arctic coastlines or island archipelagoes. In the Canadian Arctic, polar bears concentrate at the North Water polynya in Smith Sound and northwestern Baffin Bay, which contains open water all year, and at smaller permanent polynyas at Cardigan Strait-Hell Gate, Penny Strait-Queens Channel, and in the eastern entrance to Fury and Hecla Strait (Stirling 1980).

Terrestrial maternity denning areas are also essential habitat for polar bears. In Alaska, the highest density of land dens occurs along the coast of the eastern Beaufort Sea within the Arctic National Wildlife Refuge and immediately surrounding area ("Arctic Refuge") (Amstrup 1993; FWS 1995). Bluffs along beaches and cut banks along rivers provide topographic relief for maternity dens dug into drifted snow (FWS 1995). Land dens are not limited to the immediate coastline. Some have occurred inland approximately 48 kilometers from shore (FWS 1995). Polar bear dens have also been found recently in the area of the proposed Liberty well development (MMS 2003). Barrier islands in shallow water along the northern and western coasts of Alaska are also important denning habitat (FWS 1995). Flaxman, Pingok, Cross, Cottle, Thetis, and other barrier islands in the Beaufort Sea are known to support maternity dens (FWS 1995). Other important denning areas in Alaska include (East of Point Barrow) the Kachiksuk Bluffs, Point Poleakoon in Smith Bay, at the mouths of the Nechelik and Kuprigruak channels of the Colville River, and the Oliktok Point area (FWS 1995). West of Point Barrow, near Wainwright, bears den along the Kuk River and tributary drainages, uplands, coastal areas and barrier islands near Icy Cape, and areas near Point Belcher (FWS 1995). Near Point Lay bears den in the Kukpowruk River drainage, coastal areas near Cape Sabine, Cape Beaufort, Cape Dyer, and Cape Thompson (FWS 1995).

Other areas of high density polar bear denning worldwide include the islands of Kong Karls Land, Nordaustlandet, Edgeøya, and Barentstøya in the Svalbard Archipelago north of Norway (Larsen 1985), Franz Josef Land, Novaya Zemlya, and Wrangel Island in Russia, and the west coast of Hudson Bay in Canada (Amstrup 2002). Other known denning areas include the western and southern coasts of Banks Island, Herschel Island, the tip of the Tuktoyaktuk Peninsula, and Baillie Islands and the tip of the adjacent peninsula (Stirling 1998:194).

## Recommendations for Further Research

Several scientific experts have made important recommendations regarding research for monitoring the impacts of global warming on polar bear populations. We include these points here because future research will be essential to saving the polar bear from extinction. The FWS should consider these points in its recovery plan process and in its research funding decisions.

The greatest challenge will be to implement the appropriate studies to monitor and document ecosystem responses to global warming (Derocher et al. 2004). For the polar bear, Derocher et al. (2004) suggest that monitoring a suite of parameters including body mass, growth rates, cub survival, reproductive rates within focal populations, and the sex ratio of harvest will yield the greatest insight. They discourage emphasis on monitoring the global population size as this is impractical and not particularly useful because bears in different areas will respond differently to climate change (Derocher et al. 2004). Parameters such as adult survival rates will have a large impact on population trend but are difficult and expensive to measure, and lack of good long-term baseline data in most areas makes interpreting the results of new monitoring programs more difficult (Derocher et al. 2004). The High Arctic Islands are almost certain to become an important refuge for polar bears, but this is among the least studied area of anywhere in Canada (Derocher et al. 2004).

For research recommendations in more general areas including movement patterns, maternal denning, population numbers, reproduction, survival, and jurisdictional inequalities, see Amstrup (2003: 605-6).

## Appendix A: Designation of Distinct Population Segments and Genetic Structure of Polar Bear Populations

The FWS is charged with making a determination, within 90 days of receipt of this petition, whether the petition presents "substantial scientific or commercial information indicating that the petitioned action may be warranted." 16 U.S.C. § 1533(a)(3)(A). This determination is known as the "90-Day Finding." If the FWS finds that there is substantial information indicating that listing may be warranted, then the FWS must promptly commence a status review of the species. In short, the petition need not prove that listing "is warranted," but need only show that it "may be warranted."

The FWS must apply this same standard to its determination of whether to designate distinct population segments with the global polar bear species for the purposes of listing under the ESA. At the 90-Day Finding Stage the FWS must evaluate whether each polar bear population "may qualify" as a distinct population segment, and if so, must commence a review of whether each does in fact qualify as such as part of its status review.[11]

The Polar Bear Specialist Group (PBSG) classifies 20 "discrete" polar bear populations for the purposes of management. This fact alone is more than enough to meet the standard that each population "may qualify" as a distinct population segment. Below, we present substantial additional information that each polar bear population meets the FWS's criteria for a distinct population segment. Additionally and alternatively, we present substantial information that each higher-level polar bear population cluster also qualifies as a distinct population segment.

Because the information presented here far exceeds the standard that designation of each polar bear population or population cluster "may be warranted" the FWS must consider each separately for listing in its status review.

### I. Criteria for Designation of a Distinct Population Segment under the Endangered Species Act

The ESA provides for the listing of all species that warrant the protections afforded by the Act. The term "species" is defined broadly under the Act to include not just biological species but also "any subspecies of fish or wildlife or plants and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature." 16 U.S.C. § 1532 (16).

The U.S. Fish and Wildlife Service ("FWS") and the National Marine Fisheries Service ("NMFS") have published a policy to define a "distinct population segment" for the purposes of listing,

[11] FWS has stated that it is the agency's policy to evaluate, on its own initiative, in the process of determining whether a petition for listing presents substantial evidence indicating that listing may be warranted, not only whether the full species may qualify for listing, but also whether any distinct populations segments may qualify for listing, and vice versa if a petition requests listing only for a distinct population segment. See, e.g. Friends of the Wild Swan v. U.S. Fish and Wildlife Service, 12 F. Supp. 2d 1121, 1133-1134 (D. Or. 1997). Even in the absence of a specific request, the FWS must evaluate the existence of and status of distinct population segments of the polar bear. Nevertheless, Petitioner specifically requests that the FWS determine whether each of the 20 polar bear populations recognized by the PBSG qualifies as a distinct population segment, and if so, whether each qualifies for listing as threatened or endangered. Additionally and alternatively, Petitioner requests that the FWS consider whether each of the four polar bear population clusters qualifies as a distinct population segment, and if so, if it qualifies for listing. The FWS must address the entire scope of this petition in its petition finding. Id. at 1134.

delisting, and reclassifying species under the ESA ("DPS Policy"). 61 Fed. Reg. 4722 (February 7, 1996). Under this policy, population segments that are both "discrete" and "significant" are considered for listing under the ESA.[12]

Under the DPS Policy, a population segment of a vertebrate species is considered discrete if it satisfies either of the following conditions:

1. It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors. Quantitative measures of genetic or morphological discontinuity may provide evidence of this separation.

2. It is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the Act.

61 Fed. Reg. 4725.

According to the DPS policy, once a population is established as discrete, its biological and ecological significance should then be considered. This consideration may include, but is not limited to, the following:

1. Persistence of the discrete population segment in an ecological setting unusual or unique to this taxon.

2. Evidence that loss of the discrete population would result in a significant gap in the range of a taxon.

3. Evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historical range.

4. Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

61 Fed. Reg. 4722.

As detailed below, each of the 20 polar bear populations meets the criteria for designation as a distinct population segment under the DPS Policy. Four clusters of polar bear populations have also been delineated based on genetic analysis. Additionally and alternatively, each of these population clusters also qualifies as a distinct population segment under the ESA. Therefore, the FWS must evaluate whether each of the 20 polar bear populations, and/or each of the four larger polar bear population clusters, qualifies for listing as a distinct population segment.

[12] The ESA requires that any distinct population segment of a vertebrate species be considered for listing. The DPS Policy adds the additional requirement that a distinct population must also be "significant," and thus raises an additional hurdle to listing beyond that contemplated by the statute. Nevertheless, we demonstrate below that all 20 polar bear populations are both "significant" and "discrete" pursuant to the criteria of the existing DPS Policy.

## II. Each of the Twenty Polar Bear Populations Qualifies as a Distinct Population Segment under the Endangered Species Act

Scientists have defined 20 polar bear populations worldwide based on decades of intensive scientific studies of polar bear movement and behavior, and in particular based on analyses of bears in mark-recapture studies, returns of tags from bears killed by hunters, and movements of adult females with satellite radio collars (Stirling and Taylor 1999). Each of the 20 populations is discrete based on behavioral and ecological factors. The PBSG in fact explicitly uses the word "discrete" to describe the populations (Lunn et al. 2002:21). Genetic variation among polar bear populations is significantly correlated with these movement data, reinforcing the appropriateness of the population designations (Paetkau et al. 1999; Amstrup 2003).

Many of the polar bear populations are also delimited by international boundaries across which there are significant differences in the control of hunting, management of habitat, and regulatory mechanisms. While several of the populations are shared between jurisdictions, many exist only in one country where hunting regulations, habitat management, and regulatory mechanisms for protection of the polar bear differ markedly from those of adjacent jurisdictions. For example, there are currently no harvest quotas in Greenland, which is a significant difference in management compared to neighbouring Canada. The different management and regulatory mechanisms of each of the five countries with polar bear populations is reviewed in more detail below. Such differences in management based on jurisdiction further support the conclusion that the polar bear populations recognized by the PBSG meet the "discreteness" prong of the DPS policy.

The 20 populations are also each "significant" in accord with the DPS policy. Each of the polar bear populations exists in an ecological and geographic setting that differs from that of each of the other populations. The loss of any one polar bear population would result in a significant gap in the range of the taxon, which is currently circumpolar. Polar bear populations occur in areas with differing physical habitat features, such as the seasonal presence or absence of sea ice and type of sea ice, and specific prey availability. Polar bear populations also display substantial variation in behaviour and natural history in areas including reproduction and movement.

Amstrup (2003:593) summarizes these factors as follows:

> Although there may be limited spatial segregation among individual polar bears, telemetry studies have demonstrated spatial segregation among groups or stocks of polar bears in different regions (Schweinsburg and Lee 1982; Amstrup et al. 1986, 2000; Garner et al. 1990, 1994; Messier et al. 1992; Amstrup and Gardner 1994; Bethke et al. 1996; Ferguson et al. 1999), patterns in spatial segregation suggested by telemetry data, survey and reconnaissance, marking and tagging studies, and traditional knowledge resulted in recognition of 19 partially discrete polar bear groups (Lunn et al. 2002:21-35).[13] There is considerable overlap in areas occupied by members of these groups, and boundaries separating the groups have been adjusted as new data were collected. Nonetheless, these boundaries are thought to be ecologically meaningful, and the units they describe are managed as populations.

[13] Amstrup (2003) refers to 19 populations rather than the 20 described in the Lunn et. al (2002) publication cited by Amstrup. Presumably, the "missing" population is the Arctic Basin population which is outside the jurisdictional boundaries of any country and therefore the least studied and defined.

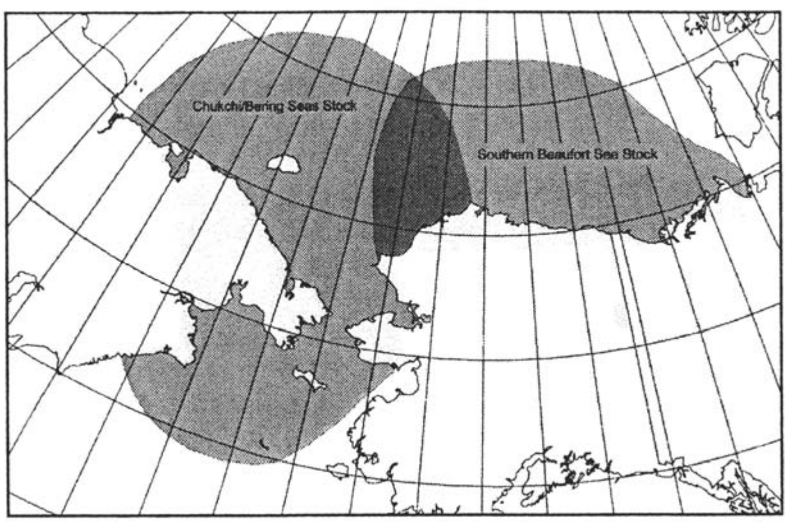
Additional factors contributing to the discreteness and significance of each of the 20 polar bear populations are discussed below in the accounts of each population. Further information on the boundaries, status, and management of each of these populations can be found in Lunn et al. (2002a).

### 1. Chukchi/Bering Seas Population or Stock (CS)(United States-Russia)

The Chukchi Sea population[14] spans both United States and Russian jurisdiction. No reliable population estimate exists for the Chukchi Sea population (Lunn et al. 2002a; Angliss and Lodge 2004). In 1988, a combined estimate for the Chukchi Sea and Southern Bering Sea stocks of 3,000 to 5,000 animals was produced based on past density studies (Angliss and Lodge 2004). A crude population estimate for the Chukchi sea stock of 1,200 to 3,200 animals was derived by subtracting the Beaufort Sea estimate of 1,800 from the total estimate for both populations (Angliss and Lodge 2004). The PBSG currently estimates the size of the Chukchi sea population at 2,000+, with the certainty of the estimate classified as poor (Lunn et al. 2002a).

Telemetry data show that polar bears are widely distributed on the pack ice of the northern Bering, Chukchi, and eastern portions of the East Siberian seas (Lunn et al. 2002a). The western boundary of the population is near Chaunskaya Bay in northeastern Russia in the East Siberian Sea and the eastern boundary is Icy Cape, Alaska, near Point Barrow, which also is the currently accepted western boundary of the Southern Beaufort Sea population (Lunn et al. 2002a; Angliss and Lodge 2004; Figure 15). The southern boundary is determined by the annual extent of pack ice (Angliss and Lodge 2004).

**Figure 15: Approximate Distribution of the Chukchi/Bering Seas and Southern Beaufort Sea Polar Bear Populations.**
Source: Angliss and Lodge (2004:195).




Dark shaded area represents distribution overlap between the Chukchi/Bering Seas and Southern Beaufort Sea populations.

[14] The U.S. Fish and Wildlife Service refers to this population as the "Chukchi/Bering Seas Stock" (Angliss and Lodge 2004), while the PBSG terms it the "Chukchi Sea population" (Lunn et al. 2002a). Except as otherwise noted, these names are used interchangeably.

Past studies have indicated that bears move very little, and only sporadically, across the eastern boundary of the populations into the Beaufort Sea (Angliss and Lodge 2004). The western boundary between the Eastern Siberian Sea stock was designated on the basis of movements of adult female polar bears captured in the Bering and Chukchi Seas region (Angliss and Lodge 2004). Female polar bears captured and radio collared on Wrangel Island exhibited no movement into the Eastern Siberian Sea, while female polar bears captured and radio collared in the Eastern Siberian Sea exhibited only limited short-term movement in the western Chukchi Sea (Angliss and Lodge 2004). To the south, adult female polar bears captured in the Beaufort Sea may make seasonal movements into the Chukchi Sea in an area of overlap located between Point Barrow and Point Hope (Angliss and Lodge 2004). Telemetry data indicated that bears marked in the Beaufort Sea spend about 25% of their time in the northeastern Chukchi Sea, and females captured in the Chukchi Sea spend only 6% of their time in the Beaufort Sea (Angliss and Lodge 2004). Radio-collared adult females spent a greater proportion of their time in areas under Russian jurisdiction than in areas under United States jurisdiction (Angliss and Lodge 2004). Historically, polar bears ranged as far south as St. Matthew Island and the Pribilof Islands (Angliss and Lodge 2004).

Amstrup et al. (2004) have published the first occurrence probabilities for polar bear populations based on new data analysis techniques. These researchers conclude that near Barrow, Alaska, 50% of bears observed can be predicted to be from the Chukchi Sea population, and 50% from the Southern Beaufort Sea population. Near Tuktoyaktuk, Northwest Territories, Canada, 50% are from the Southern Beaufort Sea and 50% from the Northern Beaufort Sea (Amstrup et al. 2004). For further information on these new techniques and the contours of polar bear population utilization distributions, see Amstrup et al. (2004).

The Chukchi/Bering Sea population is bounded on the west by the Laptev Sea population, on the east by the Southern Beaufort Sea population, and to the north by the Arctic Basin population. Figure 1; Figure 15.

Because sea ice disappears from most of the Bering and Chukchi Seas in summer, polar bears in this population may migrate as much as 1000 km north to stay with the southern edge of the pack ice (Amstrup 2003). This is a notable difference in both behavior and ecological setting compared to other polar bear populations, where the sea ice does not retreat nearly as far. It is also a significant behavioral difference compared to other populations such as Western Hudson Bay that react to seasonal retreat or disappearance of sea ice by remaining on land. An additional behavioral and ecological factor is that polar bears in the Chukchi and Bering Sea feed more heavily on Pacific walrus than polar bears in other areas (AMAP 2003).

Important denning areas in Alaska include, near Wainwright, areas along the Kuk River and tributary drainages, uplands, coastal areas and barrier islands near Icy Cape, and areas near Point Belcher (FWS 1995). Near Point Lay bears den in the Kukpowruk River drainage, coastal areas near Cape Sabine, Cape Beaufort, Cape Dyer, and Cape Thompson (FWS 1995).

In addition, the Chukchi/Bering Seas population and the Southern Beaufort Sea population, discussed below, (the only two populations that occur partially in United States jurisdiction) are classified as "stocks" under the Marine Mammal Protection Act ("MMPA"). While the analysis of whether a marine mammal population is a separate "stock" is not identical to the analysis for the designation of a distinct population segment, the stock designation strongly supports a distinct population segment designation.

## 2. Southern Beaufort Sea (SB)(United States-Canada)

The Southern Beaufort Sea polar bear population occurs in areas under both United States and Canadian jurisdiction. The PBSG reports a population abundance estimate for the Southern Beaufort Sea population of 1,800, with certainty of estimate classified as "good," and classifies the population as "increasing" (Lunn et al. 2002a).

Telemetry and other data suggested that bears from the southern Beaufort Sea comprised a single population with an eastern boundary between Paulatuk and Ballie Island, NWT, Canada, and a western boundary near Icy Cape, Alaska (Lunn et al. 2002a).

The Southern Beaufort Sea population is bounded on the west by the Chukchi/Bering Sea population, on the east and northeast by the Northern Beaufort Sea population, and to the north by the Arctic Basin population. Figure 1; Figure 15.

In contrast to polar bear populations that either den entirely on land or entirely on ice, female polar bears in the Southern Beaufort Sea population employ both strategies, with about half of the bears denning on pack ice, and about half on land. Scientists do not know whether bears have always used offshore denning areas or if it is a recent development (Stirling 2002). Two explanations for the offshore denning have been advanced. First, bears may be forced to den offshore because in some years and in some areas the pack ice does not consolidate or drift close enough to land for female polar bears to reach land in time to enter their maternity dens, and are thus forced to den offshore (Stirling 2002). Second, polar bears have been hunted by native people and whalers along the mainland coast of the southern Beaufort Sea from the Tuktoyaktuk Peninsula to western Alaska for over 100 years (Stirling 2002). This hunting may have eliminated bears that regularly returned to den on land because bears are so vulnerable to hunting during maternity denning (Stirling 2002). Because hunting of polar bears during maternity denning has now been prohibited, maternity denning on land may once again be increasing (Stirling 2002).

Of the bears that do den on land, a disproportionate number den within or close by the boundaries of the Arctic National Wildlife Refuge. Amstrup (1993) located 44 dens on land or land-fast ice along the mainland coast of Alaska and Canada between 1981-1992. Of those, 20 (45%) were within the bounds of the Arctic Refuge, and 15 (34%) were within the bounds of the 1002 Area (Amstrup 1993). The coasts of the Arctic Refuge and 1002 Area constitute only 13% and 10%, respectively, of the longitudinal range over which the mainland dens were observed (Amstrup 1993). More dens are located in the Arctic Refuge and the 1002 Area than would be expected if polar bears denned uniformly along the coast (Amstrup 1993). In addition to the 20 dens within the Arctic Refuge, one den was on lands controlled by the village of Kaktovik and surrounded by Arctic Refuge lands, two others were just offshore of the 1002 Area on land-fast ice, and numerous dens were also found in Canada just east of the Arctic Refuge (Amstrup 1993). Explanations for this high concentration include the quality of the habitat, proximity to favorable hunting, and past human pressure along other areas of the coast (FWS 1995). While currently just over half of denning activity by the Southern Beaufort Sea population appears to be on sea ice, during one study the proportion of bears denning on land appeared to be increasing (Amstrup 2000). In this area, bears appear to be faithful to type of denning habitat, but not to precise denning locations (FWS 1995). Females that denned on land were more likely to den on land again in subsequent years, and those denning on pack ice were more likely to return to pack ice (FWS 1995).

Polar bear dens have also been found recently in the area of the proposed Liberty well development (MMS 2003). Barrier islands in shallow water along the northern coast of Alaska are also important denning habitat (FWS 1995). Flaxman, Pingok, Cross, Cottle, Thetis, and other barrier islands in the Beaufort Sea are known to support maternity dens (FWS 1995). Other important denning areas in Alaska include the Kachiksuk Bluffs, Point Poleakoon in Smith Bay, at the mouths of the Nechelik and Kuprigruak channels of the Colville River, and the Oliktok Point area (FWS 1995).

The eastern Beaufort Sea, occupied by the Southern Beaufort Sea and the Northern Beaufort Sea (discussed below) polar bear populations, is an ecological setting that differs from other ecological settings occupied by polar bear populations worldwide:

> The diversity of marine mammals and seabirds in the eastern Beaufort Sea is significantly lower than in some other parts of the maritime Arctic, such as Baffin Bay to the east or the Chukchi Sea to the west. In the eastern Beaufort Sea, marine mammal diversity is restricted to polar bears, ringed seals (*Phoca hispida*), bearded seals (*Erignathus barbatus*), bowhead whales (*Baleana mysticetus*), and white whales (*Dephinapterus leucas*).
>
> Baffin Bay, in addition to these species, has large numbers of narwhals (*Monodon monoceros*), harp seals (*Pagophilus groenlandicus*), hooded seals (*Cystophora cristata*), and Atlantic walrus (*Odobenus rosmarus rosmarus*). Similarly, in the Chukchi Sea, there are several additional and abundant species of marine mammals not found in the eastern Beaufort Sea, including grey whales (*Eschrichtius robustus*), Pacific walrus (*Odobenus rosmarus divergens*), spotted seals (*Phoca largha*), and ribbon seals (*Phoca fasciata*).
>
> A comparison of the numbers and distribution of seabird colonies is even more dramatic. In northern Baffin Bay alone, colonial cliff-nesting seabirds cumulatively number in the tens of millions of individuals of several species (Brown and Nettleship, 1981). In stark contrast, despite an abundance of apparently suitable cliffs for nesting adjacent to recurrent leads and polynyas, especially on south-western Banks Island, the eastern Beaufort Sea has only one small colony of thick-billed murres (*Uria lomvia*), numbering fewer than 1000 birds (Johnson and Ward, 1985) at Cape Parry, adjacent to the Cape Bathurst poynya (Stirling 2002:61-62).

The age of first breeding for most female polar bears in both the Southern and Northern Beaufort Sea populations is five years of age, as compared to four years for bears in most other populations worldwide, and they subsequently produce their first cubs a years later as well (Stirling 2002). Most cubs in these two populations are weaned at 2.5 years of age, as compared to other populations, such as Western Hudson Bay, where some cubs are weaned at 1.5 years of age, and Viscount Melville Sound, where some cubs are not weaned until 3.5 years of age (Stirling 2002).

### 3. Northern Beaufort Sea (NB)(Canada)

Telemetry and mark-recapture studies in the eastern Beaufort Sea conducted since the early 1970s have revealed a distinction between the populations in the north and south Beaufort Sea area, leading to the recognition of a Northern Beaufort Sea population (Lunn et al. 2002a). The density of polar bears using the multi-year ice of the northernmost area is lower than it is further south (Lunn et al. 2002a). The PBSG estimates 1,200 animals in this population with a "good" certainty of estimate (Lunn et al. 2002a). The PBSG states that current harvest appears to be within sustainable limits (Lunn et al. 2002a).

The Northern Beaufort Sea population is bounded on the west by the Southern Beaufort Sea population, on the east by the M'Clintock Channel, Viscount Melville Sound, and Queen Elizabeth populations, and to the north by the Arctic Basin population. Figure 1.

### 4. Queen Elizabeth (QE) (Canada)

The Queen Elizabeth population occurs in northern Canada north of the Viscount Melville Sound, Norwegian Bay, and Kane Basin populations, east of the Northern Beaufort Sea population, and south of the Arctic Basin population. Figure 1. It is a geographic "catch-all" population which accounts for the polar bears not included in other Canadian populations (Stirling and Taylor 1999; Lunn et al. 2002a). Polar bears occur at low densities in this region, which is characterized by heavy multi-year ice, except for a recurring lead system that runs along the Queen Elizabeth Islands from the northeastern Beaufort Sea to northern Greenland (Stirling and Taylor 1999; Lunn et al. 2002a). An estimated 200 polar bears are resident in this area, and others are known to move through the area or use it for a portion of the year (Stirling and Taylor 1999; Lunn et al. 2002a). The PBSG classifies the certainty of estimate for the 200-bear estimate as "poor" (Lunn et al. 2002a). This population is not harvested, with the exception of an occasional defense kill (Stirling and Taylor 1999; Lunn et al. 2002a). Because of the low numbers and low rate of reproduction that is likely in this population, even a small amount of incidental take could cause population depletion if human activity in this remote area becomes more common (Stirling and Taylor 1999; Lunn et al. 2002a).

### 5. Viscount Melville Sound (VM) (Canada)

The Viscount Melville Sound population is bounded on the west and southwest by the Northern Beaufort Sea population, on the south and east by the M'Clintock Channel population, on the east by the Lancaster Sound population, and on the north by the Queen Elizabeth population. Figure 1. The PBSG estimates the population size at 230 with a "fair" certainty of estimate (Lunn et al. 2002a). A five-year study of movements and population size, using telemetry and mark-recapture, was completed in 1992 on the Viscount Melville Sound population and used to define the population boundaries (Lunn et al. 2002a). This area is characterized by heavy multi-year ice and low densities of ringed seals and therefore the productivity and density of polar bears is lower than areas of comparable size (Stirling and Taylor 1999; Lunn et al. 2002a). In the Viscount Melville Sound population, some cubs are not weaned until 3.5 years of age, as opposed to the rest of worldwide polar bear populations, where most cubs are weaned at 2.5 years of age, or even 1.5 years of age in Western Hudson Bay (Stirling 2002). Overharvest likely occurred until quotas were reduced and a five-year harvest moratorium was instituted in 1994 (Lunn et al. 2002a).

### 6. Norwegian Bay (NW) (Canada)

The Norwegian Bay population is bounded on the west and north by the Queen Elizabeth population, on the east by the Kane Basin population, and on the south by the Lancaster Sound population. Figure 1.

Both COSEWIC and the PBSG currently estimate the population size as 100 animals (Stirling and Taylor 1999; Lunn et al. 2002a), with the PBSG classifying the certainty of estimate as "fair." The Norwegian Bay population is bounded by heavy multi-year ice to the west, islands to the north, east, and west and polynyas to the south (Stirling and Taylor 1999; Lunn et al. 2002a). Based on mark-recapture studies and satellite tracking of adult female polar bears, it appears that most of the bears in this population are concentrated along the coastal tide cracks and ridges along the north, east, and southern boundaries (Stirling and Taylor 1999; Lunn et al. 2002a). The year-long heavy multi-year ice through most of the central and western areas supports low densities of ringed seals and, consequently, low densities of polar bears (Stirling and Taylor 1999; Lunn et al. 2002a).

The Norwegian Bay population has a relatively high degree of genetic differentiation from other polar bear populations both regionally and globally (Paetkau et al. 1999). Paetkau et al. (1999:1580) stated "[a]ssuming that the genetic data reflect actual rates of movement, a more conservative management strategy is merited to account for the extra risk this isolation presents." Of the 20 polar bear populations for this one there currently exists the strongest genetic evidence of both "discreteness" and "significance".

## 7. Lancaster Sound (LS) (Canada)

The Lancaster Sound population is bounded on the west by the Viscount Melville Sound population, on the north by the Norwegian Bay and Kane Basin populations, on the east by the Baffin Bay population, and on the south by the M'Clintock Channel, Gulf of Boothia, and Foxe Basin populations. Figure 1. A current estimate of 1,700 is based on a preliminary analysis of both historical and current mark-recapture data, which compares favorably with a previous estimate of 1,675 that included Norwegian Bay and was considered to be conservative (Stirling and Taylor 1999; Lunn et al. 2002a). The PBSG classifies the certainty of estimate for the 1,700 population estimate as "fair" (Lunn et al. 2002a).

The central and western portion of the area occupied by the Lancaster Sound population of polar bears is characterized by high biological productivity and high densities of ringed seals and polar bears (Stirling and Taylor 1999; Lunn et al. 2002a). The western third of this region (eastern Viscount Melville Sound) is dominated by heavy multi-year ice, where, due to low densities of ringed seals, there is an inferred low biological productivity (Stirling and Taylor 1999; Lunn et al. 2002a). In the spring and summer, densities of polar bears in the western third of the area occupied by the Lancaster Sound population are low but, as break-up occurs, polar bears begin to move west to spend the summer on the multi-year pack (Stirling and Taylor 1999; Lunn et al. 2002a). Information on the movements of adult female polar bears monitored by satellite radio collars, and mark-recapture data from past years, has shown that this population is distinct from the adjoining Viscount Melville Sound, M'Clintock Channel, Gulf of Boothia, Baffin Bay and Norwegian Bay populations (Lunn et al. 2002a; Stirling and Taylor 1999).

## 8. M'Clintock Channel (MC) (Canada)

The M'Clintock Channel population is bounded on the west by the Northern Beaufort Sea population, on the north by the Viscount Melville Sound and Lancaster Sound populations, and on the east by the Gulf of Boothia, and Foxe Basin populations. Figure 1. The M'Clintock Channel population has been overharvested for some time. The most recent analysis has resulted in a current estimate of 350 bears and the PBSG classifies the certainty of this estimate as "fair" (Lunn et al. 2002a). The current M'Clintock Channel population boundaries are based upon the recovery of tagged bears and the movements of adult females with satellite radio-collars in adjacent areas (Stirling and Taylor 1999; Lunn et al. 2002a). These boundaries appear to be a consequence of large islands to the east and west, the mainland to the south, and the heavy multi-year ice in Viscount Melville Sound to the north (Stirling and Taylor 1999; Lunn et al. 2002a).

### 9. Gulf of Boothia (GB) (Canada)

The Gulf of Boothia population is bounded on the west by the M'Clintock Channel population, on the north by the Lancaster Sound population, and on the east and south by the Foxe Basin populations. Figure 1. The PBSG classifies the certainty of the 900-animal estimate for the Gulf of Boothia population as "poor" and lists the status of the population as stationary on an "uncertain and tentative" basis (Lunn et al. 2002a).

The population boundaries of the Gulf of Boothia population are based on movements of tagged bears, movements of adult females with satellite radio-collars in adjacent areas, and interpretations by local Inuit hunters of how local conditions influence the movements of polar bears in the area (Stirling and Taylor 1999; Lunn et al. 2002a).

### 10. Foxe Basin (FB) (Canada)

The Foxe Basin population is bounded on the west by the M'Clintock Channel and Gulf of Boothia populations, on the north by the Lancaster Sound and Baffin Bay populations, on the east by the Davis Strait population, and on the south by the Western and Southern Hudson Bay populations. Figure 1. The current estimate of 2,300 for the Foxe Basin population was developed in 1996 from a mark-recapture program based on tetracycline biomarkers (Stirling and Taylor 1999; Lunn et al. 2002a).

The Foxe Basin population occupies Foxe Basin, northern Hudson Bay, and the western end of Hudson Strait, based on 12 years of mark-recapture studies, a limited amount of tracking of female bears with conventional radios, and satellite tracking of adult females (Stirling and Taylor 1999; Lunn et al. 2002a). During the ice-free season, polar bears were concentrated on Southampton Island and along the Wager Bay coast (Stirling and Taylor 1999; Lunn et al. 2002a). Significant numbers of bears have also been encountered on the islands and coastal regions throughout the Foxe Basin area (Stirling and Taylor 1999; Lunn et al. 2002a).

### 11. Western Hudson Bay (WH) (Canada)

The Western Hudson Bay population is bounded on the north by the Foxe Basin population, and on the east by the Southern Hudson Bay population. Figure 1.

The Western Hudson Bay population is likely the most intensely studied and well understood of all polar bear populations worldwide. The Western Hudson Bay population lends itself to scientific research for a number of reasons including the fact that the town of Churchill is a relatively easy and inexpensive location to reach compared to other Arctic locations, the fact that the whole population comes ashore for 4 months and is concentrated within about 250 miles of Churchill, and the fact that higher temperatures and snow-free conditions for most of that time make fieldwork easier than in more northerly areas (Stirling 1998).

The distribution, abundance, and population boundaries of the Western Hudson Bay population have been studied since the late 1960s (Stirling and Taylor 1999; Lunn et al. 2002a). Over 80% of the adult population has been marked, generating extensive records from mark-recapture studies and the return of tags from bears killed by Inuit hunters (Stirling and Taylor 1999; Lunn et al. 2002a).

The PBSG classifies the certainty of the 1,200 bear population estimate as "good" (Lunn et al. 2002a).

The Western Hudson Bay population differs from other polar bear populations in several important ecological and behavioral regards. First, Western Hudson Bay, together with the eastern portion of Hudson Bay and James Bay, occupied by the Southern Hudson Bay population, represents the southernmost extreme of the species' range and differs markedly from other areas inhabited by polar bears.

Hudson Bay is connected to rest of the ocean only by narrow channels at the north end of Foxe Basin and Hudson Strait (Gough et al. 2004; Figure 10). As a result, Hudson Bay behaves like a relatively closed system (Gough et al. 2004). Hudson Bay has an average depth of 120 m, and is ice-free in the summer and freezes over in the winter (Gough et al. 2004). Thus, in the summer Hudson Bay creates a general marine climate in the surrounding area, while in the winter it is insulated by ice and snow and permits cold polar air masses to extend south into central Canada (Gough et al. 2004). Typically it is completely covered in ice from January to May and is ice-free from mid-August to late October (Gough et al. 2004). Break-up begins first in James Bay, at the southern end of Hudson Bay close to the western shoreline, due to warm winds, and also in the eastern region of Hudson Bay, from spring runoff (Gough et al. 2004). Ice that melts in the southern part of Hudson Bay is replaced through ice advection from the north (Gough et al. 2004). As a result, the last place to break up in the spring is often the southwestern region of Hudson Bay (Gough et al. 2004).

Despite their proximity, the Western Hudson Bay and Southern Hudson Bay polar bear populations are clearly discrete based on denning locations. Bears from each population may mix and interact on the sea ice in winter, but show fidelity to terrestrial denning locations, with the Western Hudson Bay population denning on the Manitoba coast and the Southern Hudson Bay denning on the Ontario coast of Hudson Bay (Stirling and Taylor 1999; Lunn et al. 2002a). The Western Hudson Bay population also differs from all other polar bear populations in that female bears do not all den close to the coastline, but may range up to 118 km inland to traditional denning areas (Amstrup 2003).

Females polar bears in the Western Hudson Bay population den exclusively on land, unlike bears in some other populations, and also undergo an eight-month fast during pregnancy, the longest of any population, due to the timing of sea-ice formation and break-up in Western Hudson Bay (Amstrup 2003). The Western Hudson Bay population is also one of the only areas where bears are known to excavate dens in the earth (in permafrost) as opposed to in the snow.

In Western Hudson Bay, about 40% of females wean their cubs at about 1.5 years of age (Stirling 1998). Stirling (1998) suggested several possible reasons for earlier weaning in this area compared to other areas. The first possibility is that softer snow due to relatively warmer temperatures in Western Hudson Bay compared to other areas of the Arctic could allow younger, lighter cubs to successfully hunt seals by breaking into their birth lairs from above the snow. The second is that Hudson Bay may be more biologically productive because of the many rivers that deposit nutrients there, leading to larger seal populations and easier hunting for polar bears. The third is that Hudson Bay has a large population of bearded seals which are four to five times larger than ringed seals and result in much larger amounts of carrion left on the ice which is disproportionately exploited by young bears (Stirling 1998).

Due to the Western Hudson Bay polar bear population's southerly location and partially terrestrial life-history strategy, this population is showing the most severe early signs of the adverse impacts of global warming, although other populations may also be suffering impacts that have not yet been documented.

### 12. Southern Hudson Bay (SH) (Canada)

The Southern Hudson Bay population is bounded on the west by the Western Hudson Bay population, on the north by the Foxe Basin population, and on the east by the Davis Strait population. Figure 1.

The PBSG classifies the certainty of the 1,000-bear population estimate for Southern Hudson Bay as "fair" (Lunn et al. 2002a). The Southern Hudson Bay population boundaries are based upon observed movements of marked bears and telemetry studies (Lunn et al. 2002a; Stirling and Taylor 1999). As described above, the Southern Hudson Bay population is clearly differentiated from the Western Hudson Bay population by the fidelity of denning female polar bears to the Ontario coast.

### 13. Kane Basin (KB) (Canada-Denmark (Greenland))

The Kane Basin population is bounded on the west by the Norwegian Bay population, on the south by the Lancaster Sound and Baffin Bay populations and to the north by the Queen Elizabeth population. Figure 1.

The PBSG uses a preliminary population estimate of 200 for the Kane Basin population, with the certainty of that estimate classified as "fair" (Lunn et al. 2002a). The Kane Basin population occurs in areas under the jurisdiction of both Canada and Denmark. The boundaries of the Kane Basin population have been defined as the North Water Polynya to the south, and Greenland and Ellesmere Island to the west, north, and east based on the movements of adult females with satellite radios and recaptures of tagged animals (Lunn et al. 2002a; Stirling and Taylor 1999). Polar bears in Kane Basin are genetically similar to those in Baffin Bay (Paetkau et al. 1999; Lunn et al. 2002a).

### 14. Baffin Bay (BB) (Canada-Denmark (Greenland))

The Baffin Bay population is bounded on the west by the Lancaster Sound population, on the south and west by the Foxe Basin population, on the south by the Davis Strait population, and to the north by the Kane Basin population. Figure 1.

The Baffin Bay population occurs in areas under the jurisdiction of both Canada and Greenland (Denmark). The PBSG estimates the current population size at 2,200 and classifies the certainty of the estimate as "fair" (Lunn et al. 2002a).

Based upon the movements of adult females with satellite radios and recaptures of tagged animals, the Baffin Bay population is bounded by the North Water Polynya to the north, Greenland to the east, and Baffin Island to the west (Lunn et al. 2002a; Stirling and Taylor 1999). With a clearly distinct southern boundary at Cape Dyer, the distinction of Baffin Island as a separate population is evident from the movements of tagged bears and recent movement data from polar bears monitored by satellite telemetry (Lunn et al. 2002a; Stirling and Taylor 1999). No genetic differences have been observed between polar bears in Baffin Bay and Kane Basin, although Baffin Bay bears differed significantly from Davis Strait and Lancaster Sound bears (Lunn et al. 2002a; Paetkau et al. 1999). Recent work has revealed that an unknown proportion of the population is typically offshore during the spring (Lunn et al. 2002a; Stirling and Taylor 1999).

### 15. Davis Strait (DS) (Canada-Denmark (Greenland))

The Davis Strait population is bounded on the west by the Southern Hudson Bay and Foxe Basin populations, on the north by the Baffin Bay population and to the east by the East Greenland population. Figure 1.

The Davis Strait Population occurs in areas under the jurisdiction of both Canada and Greenland (Denmark). The certainty of the PBSG population estimate of 1,400 is classified as "fair."

Based on the movements made by tagged animals and, more recently, of adult females with satellite radios, this population has been determined to occur in the Labrador Sea, eastern Hudson Strait, Davis Strait south of Cape Dyer, and an as yet undetermined portion of southwest Greenland (Lunn et al. 2002a; Stirling and Taylor 1999). Genetics work by Paetkau et al. (1999) has demonstrated significant differences between bears from Davis Strait and both Baffin Bay and Foxe Basin.

### 16. East Greenland (EG) (Denmark (Greenland))

The East Greenland population is bounded on the southwest by the Davis Strait population, on the east by the Barents Sea population, and on the north by the Arctic Basin population. Figure 1.

The PBSG gives a population abundance estimate of 2,000 with a "poor" certainty of estimate for the East Greenland population because no inventories have been conducted recently to determine the size of this population (Lunn et al. 2002a). Although polar bears range widely along the entire coast of eastern Greenland, various studies have indicated that resident groups of bears may occur within this range (Lunn et al. 2002a). Although Paetkau et al. (1999) found little evidence of a genetic difference between populations in the eastern Greenland and Svalbard - Franz Josef Land regions (Barents Sea population), satellite telemetry and movement of marked animals indicate that the exchange between these populations is minimal (Lunn et al. 2002a).

### 17. Barents Sea (BS) (Norway)

The Barents Sea population is bounded on the west by the East Greenland population, on the east by the Kara Sea population, and on the north by the Arctic Basin population. Figure 1.

The population size of the Barents Sea is essentially unknown, with the PBSG reporting a 2,000-5,000 animal abundance estimate with a "poor" certainty of estimate (Lunn et al. 2002a). Surveys conducted in 2004 resulted in a new population estimate of 3,000 animals, at the lower end of the 2001 PBSG estimate (Norwegian Polar Institute 2005). Studies of movements using telemetry indicate that some polar bears associated with Svalbard are very restricted in their movements but bears from the Barents Sea move widely between Svalbard and Franz Josef Land (Lunn et al. 2002a). Population boundaries are based on satellite telemetry data and the current boundaries represent a change from earlier reports (Lunn et al. 2002a). Extent of overlap between the Barents Sea and East Greenland populations is unknown but may be limited (Lunn et al. 2002a). Gene flow from East Greenland to Franz Josef Land is high (Lunn et al. 2002a; Paetkau et al. 1999). Denning in this population occurs in both Svalbard and Franz Josef Land (Lunn et al. 2002a).

The mean age of weaning for cubs in Svalbard in the Barents Sea population has also been calculated as 17 months of age, which differs significantly from the approximate age of weaning of 2.5 years that predominates across most other polar bear populations (with the exception of the Western Hudson Bay population) (Amstrup 2003).

Infanticide has also been detected more often in the Svalbard area than in other parts of the polar bear's range where relative densities of polar bears are lower (Amstrup 2003). The significance of infanticide to population regulation, however, is not well understood (Amstrup 2003).

### 18. Kara Sea (KS) (Russia)

The Kara Sea population is bounded on the west by the Barents Sea population, on the east by the Laptev Sea population, and on the north by the Arctic Basin population. Figure 1.

The PBSG lists the population estimate for this population as "unknown" without any abundance estimate (Lunn et al. 2002a). The Kara population occurs within Russian jurisdiction and includes the Kara Sea and overlaps in the west with the Barents Sea population in the area of Franz Josef Land and Novaya Zemlya archipelagos. The information for the Kara and Barents Seas, in the vicinity of Franz Josef Land and Novaya Zemlya, is mainly based on aerial surveys and den counts (Lunn et al. 2002a). Studies of movements, using telemetry, have been done throughout the area but data to define the eastern boundary are incomplete (Lunn et al. 2002a).

Bears from this population have the highest organochlorine pollution levels in the Arctic, and contaminant levels in rivers flowing into this area and recent information on nuclear and industrial waste disposal raise concerns about the possibility of environmental damage (Lunn et al. 2002a).

### 19. Laptev Sea (LS) (Russia)

The Laptev Sea population is bounded on the west by the Kara Sea population, on the east by the Chukchi Sea population, and on the north by the Arctic Basin population. Figure 1.

The PBSG lists the population estimate of 800-1,200 animals for this population, with a "poor" degree of certainty, and cautions that the data upon which the estimate is based are incomplete (Lunn et al. 2002a).

The Laptev population area includes the western half of the East Siberian Sea, the entire Laptev Sea, including the Novosibirsk and Severnaya Zemlya islands (Lunn et al. 2002a). Telemetry data from the East Siberian and the Chukchi seas support the eastern boundary (Lunn et al. 2002a). Recent telemetry data from the Kara and Laptev seas indicate the western boundary is probably Severnaya Zemlya, but data are incomplete (Lunn et al. 2002a).

### 20. Arctic Basin (International Waters)

The Arctic Basin population is a geographic “catch-all” to account for polar bears that may be resident in areas of the circumpolar Arctic, but occur outside of the territorial jurisdictions of any individual nation (Lunn et al. 2002a). The PBSG lists the population estimate for the Arctic Basin as “unknown” (Lunn et al. 2002a). It is thought that polar bears probably occur at very low densities here, although no systematic surveys have been conducted (Lunn et al. 2002a). Twelve polar bears were seen during a joint US-Canada scientific oceanographic voyage across the Arctic Basin in 1994 (Lunn et al. 2002a). It is probable that bears from neighboring populations move through the Arctic Basin or use it for a portion of the year (Lunn et al. 2002a).

## III. Genetic Structure of Polar Bear Populations and Designation of Population Clusters as Distinct Population Segments

Historically, scientists have relied to a large degree upon movement data from radio-collared polar bears to delineate the geographic boundaries of the 20 worldwide polar bear populations. In a comparison of microsatellites from 16 polar bear populations worldwide, Paetkau et al. (1999) found that genetic variation among polar bear populations is significantly correlated with these movement data, reinforcing the appropriateness of the population designations (Paetkau et al. 1999; Amstrup 2003). The correspondence between movement and genetic data allows managers to make better decisions about human activities that could have population-level impacts, such as hunting (Amstrup 2003).

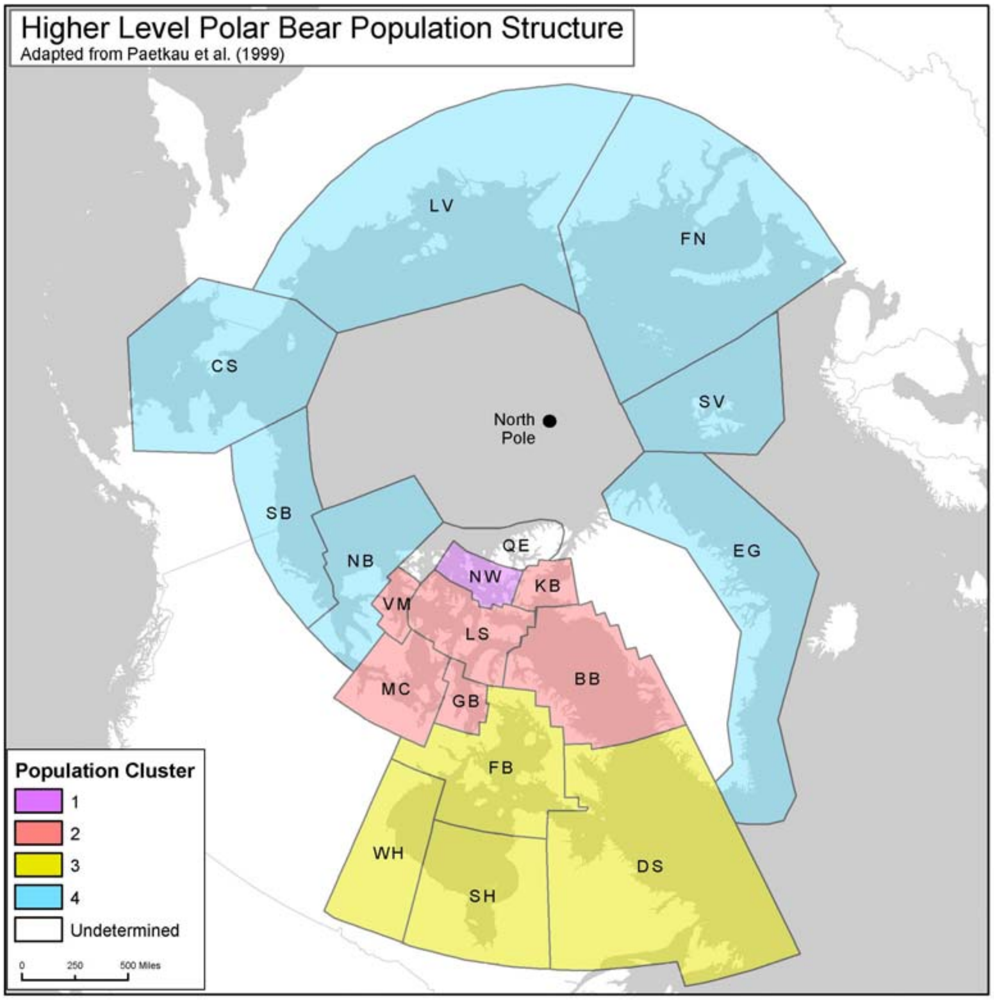
One of the most important results of the Paetkau et al. (1999) study was the identification of four population clusters that had not been previously recognized (Table 6; Figure 16).

**Table 6: Higher-Level Polar Bear Population Structure**
Source: Adapted from Paetkau et al. (1999:1578).

| Cluster | Population |
|---|---|
| Cluster 1 (Norwegian Bay) | Norwegian Bay |
| Cluster 2 (Remaining Canadian Arctic Archipelago and Populations to the East) | Viscount Melville Sound |
| | M’Clintock Channel |
| | Lancaster Sound |
| | Gulf of Boothia |
| | Baffin Bay |
| | Kane Basin |
| Cluster 3 (Southernmost Populations in Study) | Western Hudson Bay |
| | Foxe Basin |
| | Davis Strait |
| | Southern Hudson Bay* |
| Cluster 4 (Polar Basin Populations) | Northern Beaufort Sea |
| | Southern Beaufort Sea |
| | Chukchi Sea |
| | Franz Josef Land- Novaya Zemlya |
| | Svalbard |
| | East Greenland |

*Samples from Southern Hudson Bay were not available, but Paetkau et al. (1999) note that they believe Southern Hudson Bay would be included in the third population cluster. Similarly, Laptev Sea and Queen Elizabeth were not analyzed but would likely fall in Cluster 4. The Arctic Basin population was unanalyzed but would intuitively fit in this cluster also.

**Figure 16: Higher-Level Polar Bear Population Structure**
Source: Adapted from Paetkau et al. (1999:1578)




**Polar Bear Population Abbreviations**
CS – Chukchi Sea
SB – Southern Beaufort
NB – Northern Beaufort
QE – Queen Elizabeth Islands
VM – Viscount Melville Sound
NW – Norwegian Bay
LS – Lancaster Sound
MC – M'Clintock Channel
GB – Gulf of Boothia
FB – Foxe Basin
WH – Western Hudson Bay
SH – Southern Hudson Bay
KB – Kane Basin
BB – Baffin Bay
DS – Davis Strait
EG – East Greenland
SV – Svalbard
FN – Franz Josef Land – Novaya Zemlya
LV – Laptev Sea

(Paetkau et al. 1999:1580) noted that "recognition of this higher-level population structure is important because the consequences of local decline in small, isolated populations would be more severe and long lasting than for other populations" (Paetkau et al. 1999:1580).

The first, smallest and most isolated of the population clusters from both a geographic and demographic perspective is Norwegian Bay, which consists of just one population which itself is estimated to contain only 100 animals (Paetkau et al. 1999). Paetkau et al. (1999) noted that a more conservative management strategy is warranted for this population, assuming that the genetic data reflect actual rates of movement.

The second cluster contains the remaining populations in the Canadian Arctic Archipelago and the two populations between the archipelago and Greenland (Paetkau et al. 1999). Within this cluster, the most genetically distinct populations showed genetic distances similar to the smallest distances between its members and populations outside it (Paetkau et al. 1999).

The third cluster consists of the three southernmost populations included in the study (Paetkau et al. 1999). The authors noted that they believe it would also include Southern Hudson Bay, a population for which samples were not available for the study (Paetkau et al. 1999).

The fourth cluster covers a geographic area that exceeds the combined area covered by the other three clusters and consists of the three sampled populations ringing the polar basin (Paetkau et al. 1999). The largest genetic distances within this cluster were similar to the smallest distances between a member of this cluster and a conterminous population outside it (Paetkau et al. 1999). The authors noted that the study did not include complete sampling of the Queen Elizabeth Islands and Laptev Sea populations, but that they believe complete sampling would demonstrate that the pattern of genetic relationships among polar bears is circular, like the geographic relationship (Paetkau et al. 1999).

The results of Paetkau et al. (1999) demonstrate that gene flow between polar bear populations is not equal across all landscapes. There is a marked contrast between the relatively low degree of genetic structure observed among polar basin populations and the discontinuities in the Canadian Arctic Archipelago (Paetkau et al. 1999). This contrast fits well with observed movement patterns of polar bear populations in these areas (Amstrup 2003). Paetkau et al. (1999) asked why an animal with a proven ability to move long distances through difficult terrain should have strikingly different movement patterns in different parts of its range. The authors hypothesized that polar bears are unwilling, though not unable, to move even relatively short distances through areas with poor hunting opportunities, areas including land and multi-year ice with low seal densities (Paetkau et al. 1999). The authors also suggest that interactions between walrus, seals, and polar bears in the small polynya system surrounding Norwegian Bay may be operating to enhance the isolation of that population (Paetkau et al. 1999).

While there is a lack of dramatic genetic or population discontinuities across the polar bear's range, Paetkau et al. (1999) cautioned that their results do not justify the conclusion that polar bear populations do not differ significantly in terms of adaptive genetic traits.

Paetkau et al. (1999) also discussed the significance of their results for defining management units ("MUs"). Paetkau et al. (1999) discuss two definitions for MUs, the first, a genetic definition where an MU is a region with significantly different allele frequency distributions (Paetkau et al. 1999). The second is a demographic definition where an MU equals a region where local population dynamics will be driven primarily by birth and death, not by immigration and emigration (Paetkau et al. 1999). The authors found a strong relationship between the genetic and ecological definitions of MUs (Paetkau et al. 1999).

While Paetkau et al. (1999) note that the process of understanding the relationship between genetic structure, geography, and behavior is in the early stages, their work is important to the understanding of the status of and threats to the polar bear. The recognition of the four polar bear population clusters is also significant for the purposes of designating distinct population segments under the ESA. While each of the 20 polar bear populations worldwide qualifies for listing as a distinct population segment under the ESA, the case for designation each population cluster is even stronger. The geographical, physiological, and ecological differences among polar bear populations discussed are also applicable among the larger geographical areas encompassed by the four population clusters. The population clusters are discrete and significant based on the discussion of the above factors, and additionally, based on the genetics information in this section. Should the FWS choose not to designate individual polar populations as distinct population segments, the FWS must also evaluate whether each population cluster qualifies as a distinct population segment.

# Appendix B: The Impacts of Oil and Gas Exploration and Development on Polar Bears

While the polar bear as a global species is not threatened by current levels of oil and gas exploration and development, such activities pose a threat to certain populations and are likely to increase in significance in the future. Oil and gas development in the Arctic poses a wide range of threats to polar bears ranging from oil spills to increased human-bear interactions (PBSG 2005).

Activities associated with oil, gas, and mineral exploration in the Arctic can impact polar bears in a number of ways including the following: (1) damage or destruction of essential habitat; (2) contact with and ingestion of oil from acute and chronic oil spills (3) contact with and ingestion of other contaminants; (4) attraction to or disturbance by industrial noise and harassment by aircraft, ships, and other vehicles; (5) death, injury, or harassment resulting from interactions with humans; (6) increased hunting pressures; and (7) potential mortality, injury, and stress resulting from handling and interaction designed to evaluate and/or investigate impacts from all of the above factors (Lentfer 1990).

Oil and gas exploration and development activities have been most extensive in the US Arctic, and proposals to open the currently protected US Arctic National Wildlife Refuge, which contains the highest concentration of polar bear maternity dens in Alaska, as well as extensive offshore leasing in the Beaufort Sea poses a significant threat to the Southern Beaufort Sea population. Despite the fact that oil and gas development is not yet as extensive in polar bear habitat in Canadian, Norwegian, and Russian territory, it still poses a threat to many polar bear populations. In Canada, development of oil and gas leases in the Mackenzie River Delta and in the Beaufort Sea would extend oil and gas development along virtually the entire Beaufort Sea Coast occupied by the Southern Beaufort Sea polar bear population. Similarly, oil and gas development in the Norwegian and Russian Arctic poses a threat to polar bears in those areas (Derocher et al. 2002).

The first part of this Appendix summarizes the level of past, current, and future projected oil and gas development by country in or adjacent to polar bear habitat. The specific impacts of this activity on polar bears is then discussed.

## I. Existing and Projected Oil and Gas Exploration and Development

### A. United States (Alaska)

Since production began on Alaska's Arctic Slope in the early 1970s, about 14 billion barrels of oil have been extracted from underground deposits (NRC 2003). As much as 20 billion additional barrels of oil may be extracted in the future (NRC 2003). Currently there are 31 producing fields on Alaska's Arctic Slope (Minerals Management Service ("MMS") 2003; 2004; Figure 17; Table 7 (next page)). An extensive network of roads, pipelines, and power lines that connect drill sites, production facilities, support facilities, and transportation hubs sprawls from the Northeastern portion of the National Petroleum Reserve – Alaska ("National Reserve") to the Canning River and the Eastern Boundary of the Arctic National Wildlife Refuge ("Arctic Refuge") (NRC 2003; Tables 8, 9, and 10).

Seven of the 31 currently producing oil fields are offshore (MMS 2003; 2004; Table 7; Figure 17). An additional three onshore fields are in the planning stages for development but have not yet begun production (MMS 2003; 2004; Table 7). Reasonably foreseeable future development includes 16 discoveries that may undergo some development-related activities, such as site drilling, permitting, appraisal drilling, or construction, within the next 15-20 years (MMS 2003; 2004; Table 7). Over half of the fields in this category (9 of 16 fields) are offshore (MMS 2003; 2004; Table 7). "Speculative development" includes additional new discoveries that could be made and developed beyond 20 years, in conjunction with 13 past onshore discoveries (MMS 2003; 2004; Table 7).

**Figure 17: Existing Arctic Slope Oil Fields and Infrastructure**
Source: MMS (2003:Figure III.A.1)

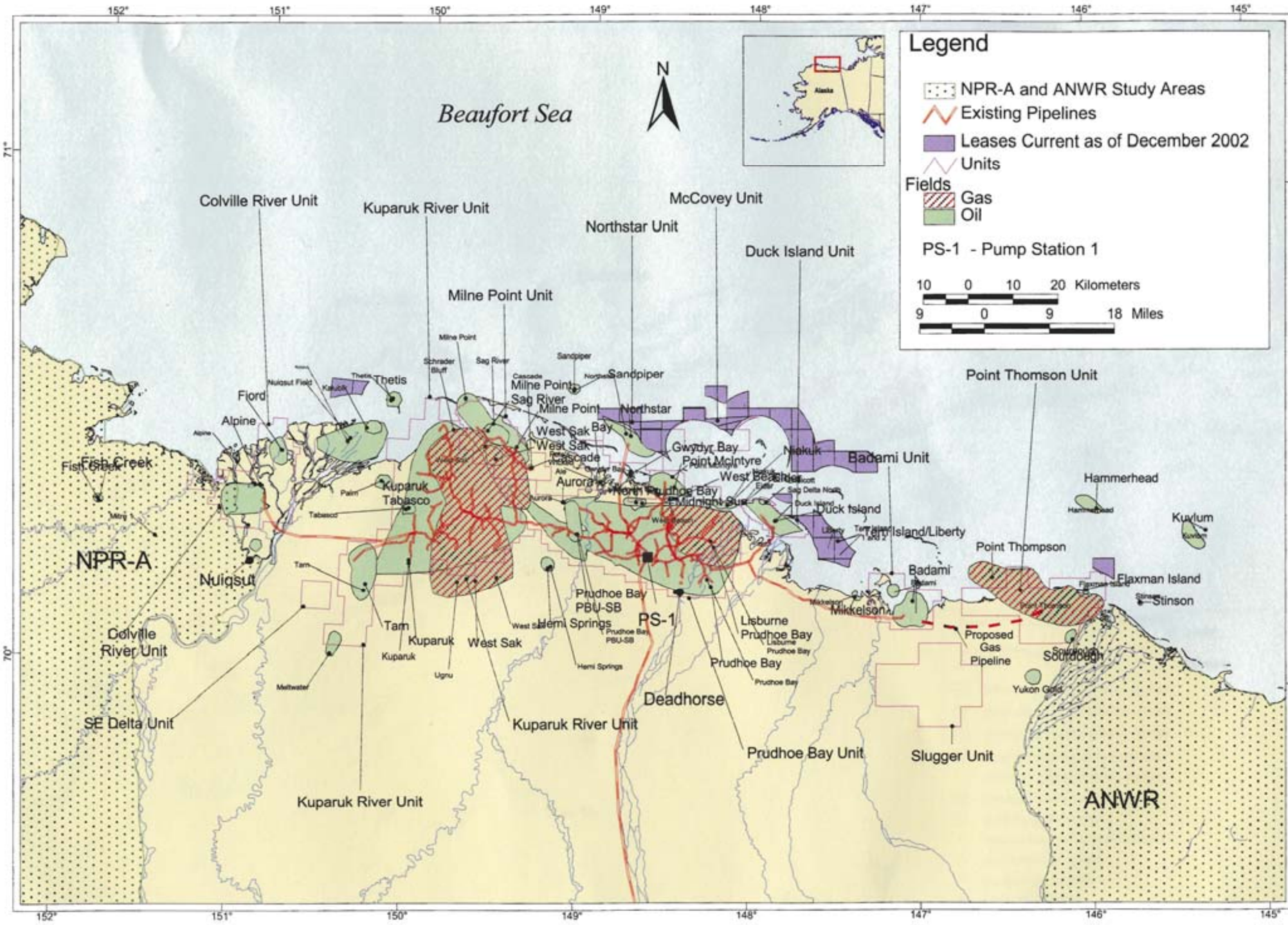



**Table 7: Past, Current and Projected Future Oil Field Development in Alaska's Arctic as of July 1, 2002**
Source: Adapted from (MMS 2003:Table V-1a).

| | Name | Location of field or pool | Production (oil/gas) | Location of production facility | Discovery | Production began | Category | Ranking criteria |
|---|---|---|---|---|---|---|---|---|
| **Past Development and Production** | | | | | | | | |
| **1** | South Barrow | Onshore | Gas | Onshore | 1949 | 1950 | Field | -- |
| **2** | Prudhoe Bay | Onshore | Oil | Onshore | 1967 | 1977 | Field | -- |
| **3** | Lisburne | Onshore | Oil | Onshore | 1967 | 1981 | Field | -- |
| **4** | Kuparuk | Onshore | Oil | Onshore | 1969 | 1981 | Field | -- |

| | Name | Location of field or pool | Production (oil/gas) | Location of production facility | Discovery | Production began | Category | Ranking criteria |
|---|---|---|---|---|---|---|---|---|
| **5** | East Barrow | Onshore | Gas | Onshore | 1974 | 1981 | Field | -- |
| **6** | Milne Point | Onshore | Oil | Onshore | 1969 | 1985 | Field | -- |
| **7** | Endicott | Offshore | Oil | Offshore | 1978 | 1986 | Field | -- |
| **8** | Sag Delta | Offshore | Oil | Onshore | 1976 | 1989 | Field | -- |
| **9** | Sag Delta North | Offshore | Oil | Offshore | 1982 | 1989 | Satellite[1] | -- |
| **10** | Schrader Bluff | Onshore | Oil | Onshore | 1969 | 1991 | Satellite[2] | When Production Began |
| **11** | Walakpa | Onshore | Gas | Onshore | 1980 | 1992 | Field | |
| **12** | Point McIntyre | Offshore | Oil | Onshore | 1988 | 1993 | Field | |
| **13** | North Prudhoe Bay | Onshore | Oil | Onshore | 1970 | 1993 | Field | -- |
| **14** | Niakuk | Offshore | Oil | Onshore | 1985 | 1994 | Field | -- |
| **15** | Sag River | Onshore | Oil | Onshore | 1969 | 1994 | Satellite[3] | -- |
| **16** | West Beach | Onshore | Oil | Onshore | 1976 | 1994 | Field | -- |
| **17** | Cascade | Onshore | Oil | Onshore | 1993 | 1996 | Field | -- |
| **18** | West Sak | Onshore | Oil | Onshore | 1969 | 1997 | Satellite[2] | -- |
| **19** | Badami | Offshore | Oil | Onshore | 1990 | 1998 | Field | -- |
| **20** | Eider | Offshore | Oil | Offshore | 1998 | 1998 | Satellite[1] | -- |
| **21** | Tarn | Onshore | Oil | Onshore | 1991 | 1998 | Field | -- |
| **22** | Tabasco | Onshore | Oil | Onshore | 1992 | 1998 | Satellite[2] | -- |
| **23** | Midnight Sun | Onshore | Oil | Onshore | 1998 | 1999 | Satellite[o] | -- |
| **24** | Alpine | Onshore | Oil | Onshore | 1994 | 2000 | Field | -- |
| **25** | Northstar | Offshore | Oil | Offshore | 1984 | 2001 | Field | -- |
| **26** | Aurora | Onshore | Oil | Onshore | 1999 | 2001 | Satellite[o] | -- |
| **27** | NW Eileen / Borealis | Onshore | Oil | Onshore | 1999 | 2001 | Field | -- |
| **28** | Polaris | Onshore | Oil | Onshore | 1999 | 2001 | Satellite | -- |
| **29** | Meltwater | Onshore | Oil | Onshore | 2000 | 2001 | Pool | -- |
| **30** | Nanuk | Onshore | Oil | Onshore | -- | 2001 | Pool | -- |
| **31** | Palm | Onshore | Oil | Onshore | 2001 | 2002 | Pool | -- |
| **Present Development** | | | | | | | | |
| **32** | CD South | Onshore | Oil | Onshore | 1996 | 2003 | Pool | When Production Began |
| **33** | CD North (Fjord) | Onshore | Oil | Onshore | 1992 | (2006) | Pool | |
| **34** | Orion | Onshore | Oil | Onshore | 2000 | -- | Satellite | |
| **Reasonably Foreseeable Future Development And Production** | | | | | | | | |
| **35** | Spark / Rendezvous | Onshore | Gas & Oil | Onshore | 2000 | -- | Prospect | -- |
| **36** | Liberty | Offshore | Oil | Offshore | 1983 | -- | Pool | -- |
| **37** | Kalubik | Offshore | Oil | Onshore | 1992 | -- | Prospect | -- |
| **38** | Pete's Wicked | Onshore | Oil | Onshore | 1997 | -- | Prospect | -- |
| **39** | Sikulik | Onshore | Gas | Onshore | 1988 | -- | Pool | -- |
| **40** | Thetis Island | Offshore | Oil | Offshore | 1993 | -- | Prospect | When We Estimate Chance and Timing of Development (highest/first |
| **41** | Gwydyr Bay | Offshore | Oil | Onshore | 1969 | -- | Pool | |
| **42** | Point Thomson | Onshore | Gas & Oil | Onshore | 1977 | -- | Pools | |
| **43** | Mikkelson | Onshore | Oil | Onshore | 1978 | -- | Prospect | |
| **44** | Sourdough | Onshore | Oil | Onshore | 1994 | -- | Pool | |

| | Name | Location of field or pool | Production (oil/gas) | Location of production facility | Discovery | Production began | Category | Ranking criteria |
|---|---|---|---|---|---|---|---|---|
| **45** | Yukon Gold | Onshore | Oil | Onshore | 1994 | -- | Prospect | to lowest/last) |
| **46** | Flaxman Island | Offshore | Oil | Offshore | 1975 | -- | Prospect | -- |
| **47** | Sandpiper | Offshore | Gas & Oil | Offshore | 1986 | -- | Pool | -- |
| **48** | Stinson | Offshore | Oil | Offshore | 1990 | -- | Prospect | -- |
| **49** | Hammerhead | Offshore | Oil | Offshore | 1985 | -- | Pool | -- |
| **50** | Kuvlum | Offshore | Oil | Offshore | 1987 | -- | Prospect | -- |
| **Speculative Future Development** | | | | | | | | |
| **51** | Hemi Springs | Onshore | Oil | Onshore | 1984 | -- | Prospect | -- |
| **52** | Ugnu | Onshore | Oil | Onshore | 1984 | -- | Pool | -- |
| **53** | Umiat | Onshore | Oil | Onshore | 1946 | -- | Pool | -- |
| **54** | Fish Creek | Onshore | Oil | Onshore | 1949 | -- | Prospect | -- |
| **55** | Simpson | Onshore | Oil | Onshore | 1950 | -- | Pool | -- |
| **56** | East Kurupa | Onshore | Gas | Onshore | 1976 | -- | Show | Insufficient Information to Estimate Chance of Development |
| **57** | Meade | Onshore | Gas | Onshore | 1950 | -- | Show | |
| **58** | Wolf Creek | Onshore | Gas | Onshore | 1951 | -- | Show | |
| **59** | Gubik | Onshore | Gas | Onshore | 1951 | -- | Pool | |
| **60** | Square Lake | Onshore | Gas | Onshore | 1952 | -- | Show | -- |
| **61** | East Umiat | Onshore | Gas | Onshore | 1964 | -- | Prospect | -- |
| **62** | Kavik | Onshore | Gas | Onshore | 1969 | -- | Show | -- |
| **63** | Kemik | Onshore | Gas | Onshore | 1972 | -- | Show | -- |

**NOTES:**
Field information is taken from State of Alaska, Department of Natural Resources (2000).
**Footnotes** for Satellites identify the associated production unit:
[1] Duck Island Unit;
[2] Kuparuk River Unit;
[3] Milne Point Unit;
[o] Prudhoe Bay Unit.
**Parentheses** indicate when production startup is expected.
**Definitions:**
Field – infrastructure (pads/wells/facilities) installed to produce one or more pools.
Satellite – a pool developed from an existing pad.
Pool – petroleum accumulation with defined limits.
Prospect – a discovery tested by several wells.
Show – a one-well discovery with poorly defined limits and production capacity.

**Table 8: Cumulative Infrastructure Point Measurements on Alaska's Arctic Slope**
Source: NRC (2003:43).

| | 1968 | 1973 | 1977 | 1983 | 1988 | 1994 | 2001 |
|---|---|---|---|---|---|---|---|
| Gravel Pads | | | | | | | |
| --Production Pads, Drill Sites | 0 | 16 | 22 | 62 | 95 | 104 | 115 |
| --Processing, facility pads | 0 | 6 | 10 | 14 | 18 | 18 | 20 |
| --Support pads (power stations camps, staging pads) | 1 | 36 | 63 | 98 | 108 | 113 | 115 |
| --Exploration Sites | 3 | 42 | 63 | 103 | 104 | 106 | 103 |
| --Offshore exploration islands | 0 | 0 | 2 | 12 | 13 | 13 | 13 |
| --Offshore production islands | 0 | 0 | 0 | 0 | 2 | 3 | 4 |
| --Airstrips | 1 | 11 | 15 | 16 | 16 | 16 | 16 |

| | 1968 | 1973 | 1977 | 1983 | 1988 | 1994 | 2001 |
|---|---|---|---|---|---|---|---|
| --Exploration Airstrips | 0 | 4 | 4 | 4 | 4 | 4 | 4 |
| Culverts | - | - | - | - | - | - | 1,395 |
| Bridges | - | - | - | - | - | - | 17 |
| Caribou Crossings | - | - | - | - | - | - | 50 |
| Landfills | - | - | - | - | - | - | 1 |

**Table 9: Cumulative Infrastructure Length (miles) on Alaska's Arctic Slope**
Source: NRC (2003:43).

| Facility or Feature | 1968 | 1973 | 1977 | 1983 | 1988 | 1994 | 2001 |
|---|---|---|---|---|---|---|---|
| Roads | 0 | 100 | 139 | 294 | 358 | 370 | 400 |
| Peat roads | 30 | 101 | 101 | 101 | 96 | 96 | 96 |
| Causeways | 0 | 0 | 2 | 3 | 8 | 8 | 8 |
| Tractor trails, tundra scars | 19 | 54 | 59 | 57 | 57 | 57 | 56 |
| Exploration roads | 0 | 36 | 36 | 36 | 36 | 36 | 36 |
| Total road length | 49 | 29 | 336 | 491 | 554 | 566 | 596 |
| | | | | | | | |
| Pipeline corridors | 0 | 100 | 139 | 294 | 358 | 370 | 400 |
| --1-5 pipes per bundle | - | - | - | - | - | - | 366 |
| --6-11 pipes per bundle | - | - | - | - | - | - | 73 |
| --12-17 pipes per bundle | - | - | - | - | - | - | 6 |
| --18-26 pipes per bundle | - | - | - | - | - | - | 4 |
| Total pipeline length | - | - | - | - | - | - | 450 |
| | | | | | | | |
| Power transmission lines | - | - | - | - | - | - | 219 |

**Table 10: Infrastructure Area (Acres) Along the Alaskan North Slope (Not Including Dalton Highway)**
Source: NRC (2003:44).

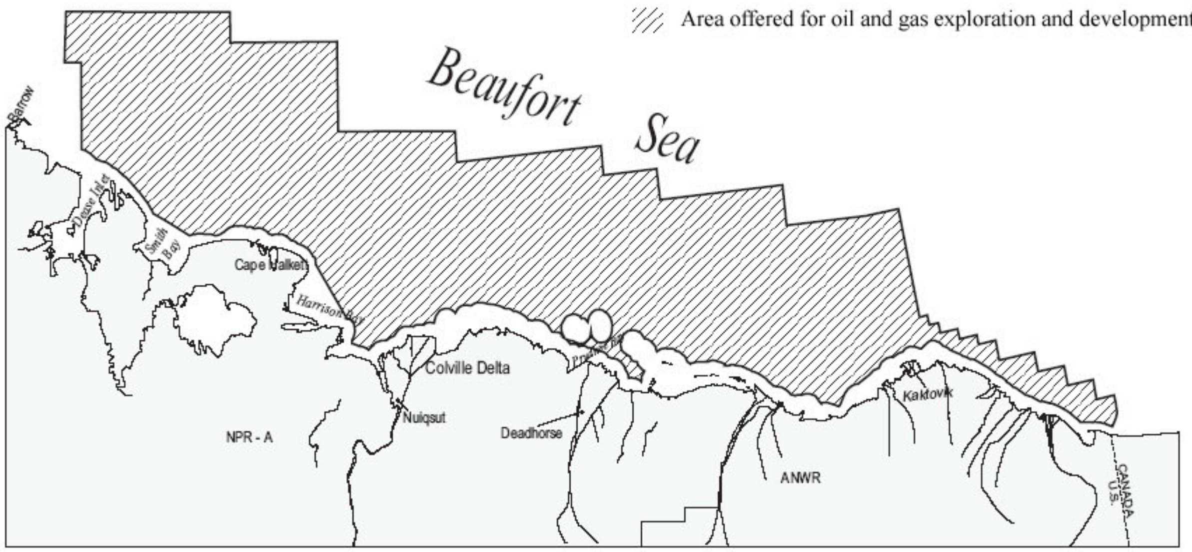
| **Infrastructure Feature** | **1968** | **1973** | **1977** | **1983** | **1988** | **1994** | **2001** |
|---|---|---|---|---|---|---|---|
| Gravel roads and causeways | | | | | | | |
| --Roads | - | 677 | 1,002 | 2,029 | 2,448 | 2,536 | 2,745 |
| --Causeways | - | 0 | 48 | 82 | 235 | 229 | 227 |
| **--Total gravel road and causeway area** | **-** | **677** | **1,050** | **2,110** | **2,683** | **2,765** | **2,971** |
| | | | | | | | |
| Airstrips (gravel or paved) | 6 | 136 | 252 | 287 | 313 | 313 | 287 |
| | | | | | | | |
| Offshore gravel pads, islands | | | | | | | |
| --Exploration islands | 0 | 0 | 5 | 54 | 57 | 57 | 53 |
| --Production islands | 0 | 0 | 0 | 0 | 76 | 92 | 101 |
| **--Total offshore gravel pad, island area** | **0** | **0** | **5** | **54** | **133** | **149** | **155** |
| | | | | | | | |
| Gravel pads | | | | | | | |
| --Production pads, drill sites | 0 | 276 | 647 | 2,199 | 2,917 | 3,019 | 3,126 |
| --Processing facility pads | 0 | 74 | 390 | 692 | 874 | 890 | 917 |
| --Support pads (camps, power stations) | 14 | 441 | 769 | 1,340 | 1,444 | 1,470 | 1,463 |
| --Exploration site | 0 | 109 | 175 | 339 | 317 | 314 | 305 |

| Infrastructure Feature | 1968 | 1973 | 1977 | 1983 | 1988 | 1994 | 2001 |
|---|---|---|---|---|---|---|---|
| **--Total gravel pad area** | **14** | **901** | **1,981** | **4,570** | **5,552** | **5,692** | **5,817** |
| | | | | | | | |
| **Total gravel footprint** | **20** | **1,713** | **3,288** | **7,022** | **8,681** | **8,919** | **9,225** |
| | | | | | | | |
| Other affected areas | | | | | | | |
| --Exploration site-disturbed area around gravel pad | 55 | 346 | 467 | 613 | 627 | 650 | 645 |
| --Exploration airstrip-thin gravel, tundra scar | 0 | 68 | 68 | 68 | 68 | 68 | 67 |
| --Peat roads | 143 | 547 | 546 | 546 | 520 | 517 | 517 |
| --Tractor trail, tundra scar | 110 | 250 | 272 | 263 | 258 | 258 | 258 |
| --Exploration roads-thin gravel, tundra scar | 0 | 177 | 179 | 177 | 178 | 178 | 177 |
| --Gravel pad removed, site in process of recovery | 0 | 1 | 21 | 27 | 46 | 81 | 100 |
| --Gravel pad removed, site is recovered | - | - | - | - | - | - | 95 |
| **--Total other affected area** | **308** | **1,388** | **1,552** | **1,694** | **1,698** | **1,753** | **1,765** |
| | | | | | | | |
| Gravel mines | | | | | | | |
| --In rivers | 25 | 4,732 | 4,996 | 5,011 | 5,063 | 5,061 | 5,082 |
| --In tundra | 0 | 34 | 151 | 745 | 1,179 | 1,186 | 1,283 |
| **--Total gravel mine area (acres)** | **25** | **4,766** | **5,146** | **5,756** | **6,241** | **6,246** | **6,364** |
| | | | | | | | |
| **Total impacted area (acres)** | **353** | **7,868** | **9,987** | **14,472** | **16,620** | **16,918** | **17,354** |

The pace of the industrialization of America's Arctic shows no signs of slowing (NRC 2003). Offshore oil development in particular is expanding now and will continue to do so in the future. Thus far, offshore oil development has accounted for only a small percentage of oil production on Alaska's Arctic slope – only about .429 billion barrels have been produced offshore compared to approximately 13.256 on shore as of December 2001 (NRC 2003). Offshore oil development represents a large proportion of reasonably foreseeable future development, and the US Government is in the process of conducting huge lease sales in the Beaufort Sea and actively promoting oil production in Alaska's Arctic.

In May, 2001, the United States President issued Executive Order 13212 which directed US departments and agencies to take appropriate actions to expedite projects that increase the production, transmission, or conservation of energy (MMS 2003; 2004). In April 2002, the US Secretary of the Interior issued a Proposed Final 5-Year Offshore Oil and Gas Leasing Program for 2002-2007 (MMS 2003; 2004). It includes three lease sales on the Beaufort Sea outer continental shelf – Sale 186 conducted in 2003, Sale 195 scheduled for 2005, and Sale 2002 scheduled for 2007 (collectively "Beaufort Sea Multiple Lease Sale") (MMS 2003; Figure 18 (next page)). Each sale offers 1,877 whole or partial lease blocks in the Beaufort Sea Planning Area, covering approximately 9.8 <u>million</u> acres for leasing (MMS 2003). To increase the number of tracts leased and to encourage exploration and development, the MMS reduced the royalties on oil production for Sale 186, and lowered the minimum bid amount and rental rates for tracts leased in Sale 186 (MMS 2004). The MMS plans to implement these leasing incentives for sale 195 as well, assuming that the price of oil is in the $18-39 per barrel price range (MMS 2004). The MMS states that at "very high" oil prices of $39 per barrel and above, incentives would not be needed because the high price alone would spur exploration and development activities (MMS 2004:3).

**Figure 18: Minerals Management Service Lease Sales 186, 195, and 2002, from 2003-2007**
Source: Adapted from MMS (2003).




Lease Sale 186 was held on September 24, 2003, and the MMS received bids on 33 tracts, including 24 near Smith Bay, approximately 80 miles west of Prudhoe Bay (MMS 2004).

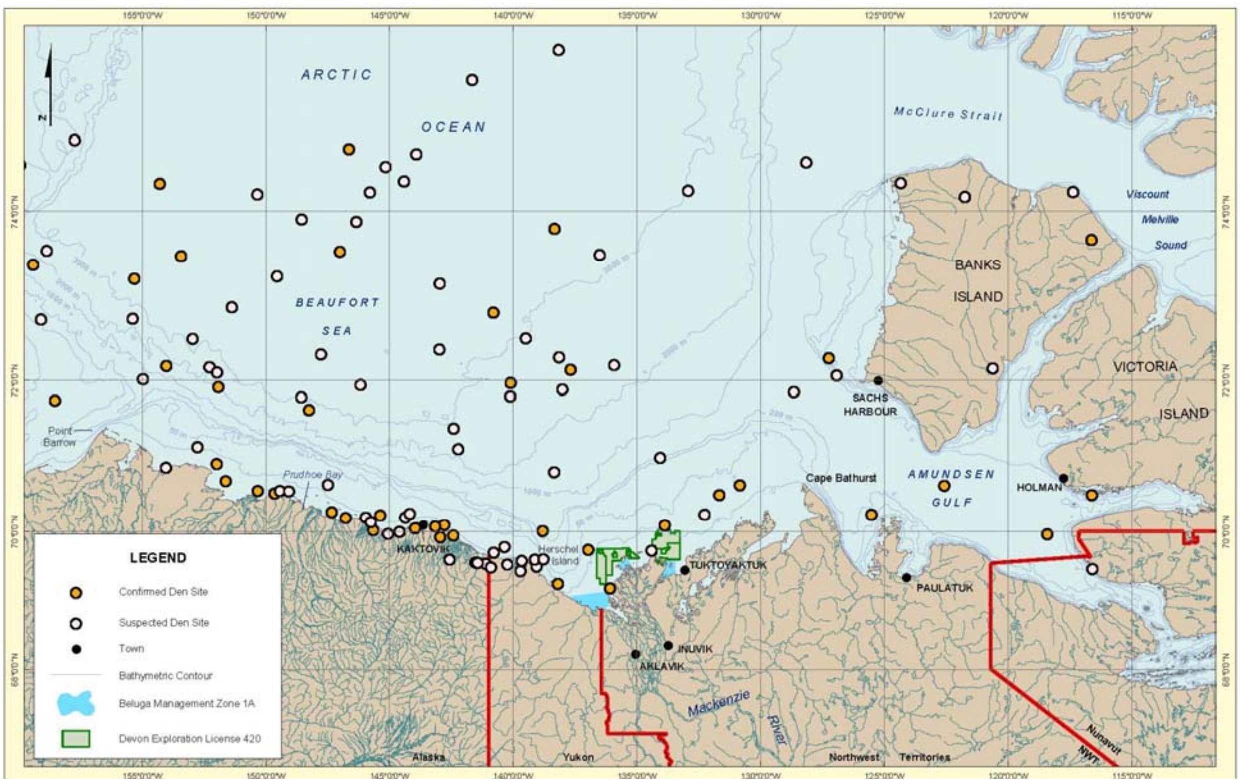
Other developments planned or proposed for Alaska's Arctic will contribute to the cumulative impact of development. These include a proposal for a gas pipeline to transport natural gas from the Arctic to market, and the State of Alaska's proposal to expand the Arctic Slope road networks connecting the Arctic Slope villages to Interior Alaska and to the North American Road network (MMS 2004). In November 2003, the State of Alaska announced that it would submit a wetlands development application to the Army Corps for the construction of a 105 mile long highway joining the Dalton Highway with the village of Nuiqsut (MMS 2004). Oil companies support this road proposal, which would begin on the Dalton Highway 57 miles south of Deadhorse and parallel the Brooks Range before swinging north 40 miles to Nuiqsut (MMS 2004). A road along the Colville River to Nuiqsut is also proposed (MMS 2004). Road developments such as these will continue opening the Arctic to increased development and impacts.

While not all existing and future oil and gas development is within polar bear habitat, it is important to note that development is currently expanding rapidly into polar bear habitat, especially in offshore areas. Moreover, even development that is not itself within polar bear habitat can indirectly impact polar bears in a number of ways, including by increasing human-bear interactions and hunter access to polar bear habitat. Similarly, further oil and gas production eventually translates into further greenhouse gas production, furthering global warming's impact on the polar bear and its habitat.

## B. Canada

Intense exploration occurred in the Canadian Beaufort Sea in the 1970s and 1980s, including 85 offshore exploration programs that resulted in significant oil and gas discoveries (Devon Canada Corporation 2004). After a lull of two decades, activity is once again increasing. The Canadian government has granted the Devon Canada Corporation Exploration License ("EL") 420 to conduct petroleum exploration within polar bear habitat in the Southern Beaufort Sea (Devon Canada Corporation 2004; Figure 19). Devon has identified nine offshore drilling targets within the landfast ice zone (Devon Canada Corporation 2004). Under Canadian law, Devon must commence drilling at least one well in each of the four areas shown on Figure 19 by the end of the license period on August 15, 2009, or lose the license in that area, with rights reverting back to the federal government (Devon Canada Corporation 2004). Devon plans to drill the first well during the winter of 2005-2006, and one well per winter season thereafter through 2009 (Devon Canada Corporation 2004).

**Figure 19: Exploration License 420 Project Area and Suspected and Confirmed Polar Bear Dens**
Source: Devon Canada Corporation (2004:16-6)




EL 420 is located in the shallow waters of the continental shelf in the Beaufort Sea (Devon Canada Corporation 2004; Figure 19). Freeze-up currently begins in early to mid-October, with the outer edge of the landfast ice stabilizing beyond the location of the nine well locations by mid-December to mid-January (Devon Canada Corporation 2004). By late July, the project area is generally clear of ice, though strong northerly winds can still move pack ice into near shore waters (Devon Canada Corporation 2004). Polar bear hunting, both for subsistence and for sport, is an important activity in the project area (Devon Canada Corporation 2004).

The only other producing facility in the area is the Ikhil project, a single gas well that supplies natural gas to the town of Inuvik (Devon Canada Corporation 2004). The largest potential future development in the region is the Mackenzie Gas Project, a pipeline through the Mackenzie River corridor to transport natural gas to market (Devon Canada Corporation 2004). The proposed gas pipeline has spurred a great deal of exploration for natural gas in the Mackenzie Delta and parts of the Tuktoyaktuk Peninsula (MMS 2003; Devon Canada Corporation 2004).

While oil and gas exploration and development are not as active in the rest of the Canadian Arctic as it is in the Southern Beaufort Sea region, these areas are not protected from future development. As oil and gas infrastructure is introduced, development of adjacent areas becomes increasingly cost-effective and therefore increasingly likely. Future development of unprotected areas threatens polar bears.

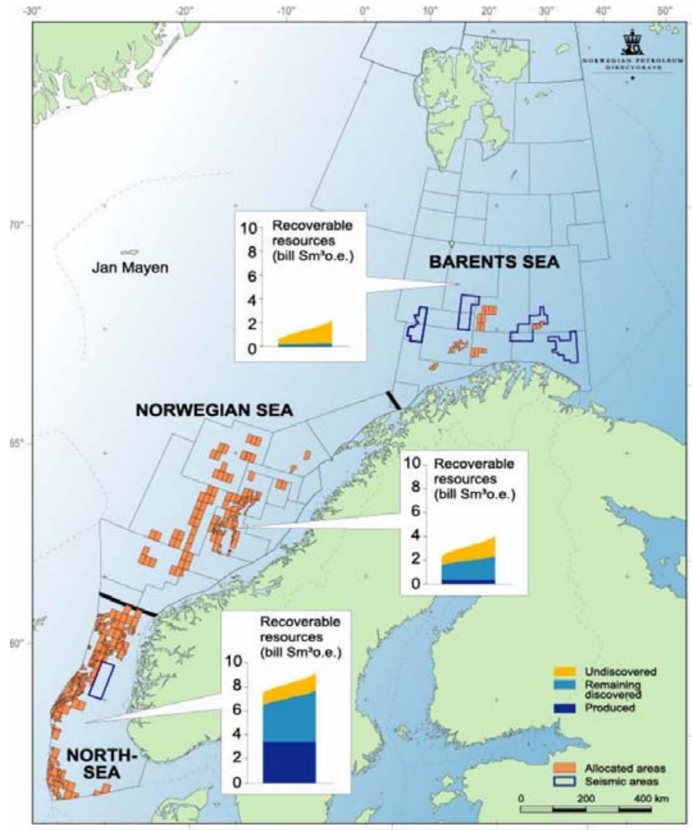
### C. Norway

Norway's oil and gas sector is well developed and accounted for 45.9% of the value of Norwegian exports and 24.8% of overall government revenue in 2003 (Andresen and Gooderham 2004). Despite these statistics, oil and gas development in polar bear habitat in Norwegian territory is a relatively recent phenomenon, because the vast majority of previous development has occurred in the North and Norwegian Seas. In May 1997, the Norwegian government awarded production licenses for seven areas of the Barents Sea, including four as seismic testing areas (Larstad and Gooderham 2004; Figure 20 (next page)). In December 2003, the Norwegian government opened areas of the southern Barents Sea to continued year-round petroleum operations, with the exception of certain areas that will be re-assessed in an integrated management plan for the Barents Sea (Andresen and Gooderham 2004).

The first producing oil field in this area, the Snøhvit field, was approved in 2002 and is expected to begin producing in 2005 (Andresen and Gooderham 2004; Larstad and Gooderham 2004). In order to promote the discovery of additional gas resources near Snøhvit, the Norwegian government included an area close to Snøhvit in the announcement of awards in pre-defined areas for 2004 (Larstad and Gooderham 2004). A facility is also under construction at Melkøya outside of Hammerfest to process gas and natural gas liquids from Snøhvit, with plans calling for production to begin in 2006 (Andresen and Gooderham 2004). While the government has recognized the special environmental constraints of oil production in the Barents Sea region (Andresen and Gooderham 2004; Larstad and Gooderham 2004), this has not stopped exploration and development activities, and oil and gas development in the Norwegian Arctic in polar bear habitat can be expected to continue to increase. Economic forces will create enormous pressure for eventual oil and gas development in the northern Barents Sea as well (Derocher et al. 2002).

**Figure 21: Norwegian Oil and Gas Licensing in the Barents Sea South of Svalbard**
Source: Larstad and Gooderham (2004:52).

**Figure 20: West Greenland Oil Exploration Licensing Areas Source: Adapted from GBMP (2005b:3).**





1: Lady Franklin Basin (approx. 10,500 km$^2$)
2: Kangaamiut Basin (approx. 4,900 km$^2$)
3: Ikermiut Ridge (approx. 7,000 km$^2$)
4: Paamiut Basin (approx. 11,200 km$^2$)

## D. Denmark (Greenland)

The Greenland and Danish governments have been actively promoting oil and gas exploration and development off the coast of Greenland, and oil and gas activities have been increasing steadily in the past several years (GBMP 2004). Following licensing rounds in 2002, the 3,985 km$^2$ Attamik license area about 200 km northwest of Nuuk, Greenland was licensed to the private oil company EnCana corporation and NUNAOIL A/S, a state-owned oil company (GBMP 2004). In 2003, EnCana carried out extensive exploration off the coast of West Greenland (GBMP 2004). An area of over 50,000 km$^2$ has been subjected to seismic testing since 1990, and seismic testing was conducted over a 9,000 km$^2$ area in 2003 alone (GBMP 2004).

In 2004 Greenland opened four areas off the west coast of Greenland in the Labrador Sea, Davis Strait, and Baffin Bay to oil exploration (Figure 21). Following this licensing round, a 2,897 km$^2$ area was licensed to EnCana and NUNAOIL over the Lady Franklin Basin (GBMP 2005a).

Recent testing has indicated possible large petroleum deposits offshore of Western Greenland (GBMP 2005). The Labrador Sea, Davis Strait, and Baffin Bay all pose serious challenges to oil exploration and development, including extreme climates and broken ice conditions for much of the year (GBMP 2004). For these reasons, increasing oil exploration and development off the West Coast of Greenland pose a significant threat to the Baffin Bay, Davis Strait, and Kane Basin polar bear populations. Due to the Greenland and Danish governments' active promotion of hydrocarbon development, oil exploration and development off the East Coast of Greenland may increase rapidly in the future as well.

### E. Russia

Parallel plans for oil and gas development in the Russian Barents Sea are also moving forward (Derocher et al. 2002). The Russian government has approved plans for a privately owned oil pipeline from Russia's oil fields to Murmansk in North-west Russia (WWF 2003). Large offshore oil and gas fields are likely to be developed within a few years (WWF 2003). Should the pipeline be built, the port on the Russian coast could become a major oil distribution terminal by 2007 (WWF 2003). Approximately 2.5 million barrels of oil a day would be transported by tanker from Murmansk to the US through the Barents Sea (WWF 2003).

There are also plans for industrial oil production on the oil fields in the southeastern part of the Barents Sea and gas production on Yamal Peninsula which would impact polar bears (Belikov et al. 2002).

## I. CURRENT AND PROJECTED IMPACTS TO POLAR BEARS

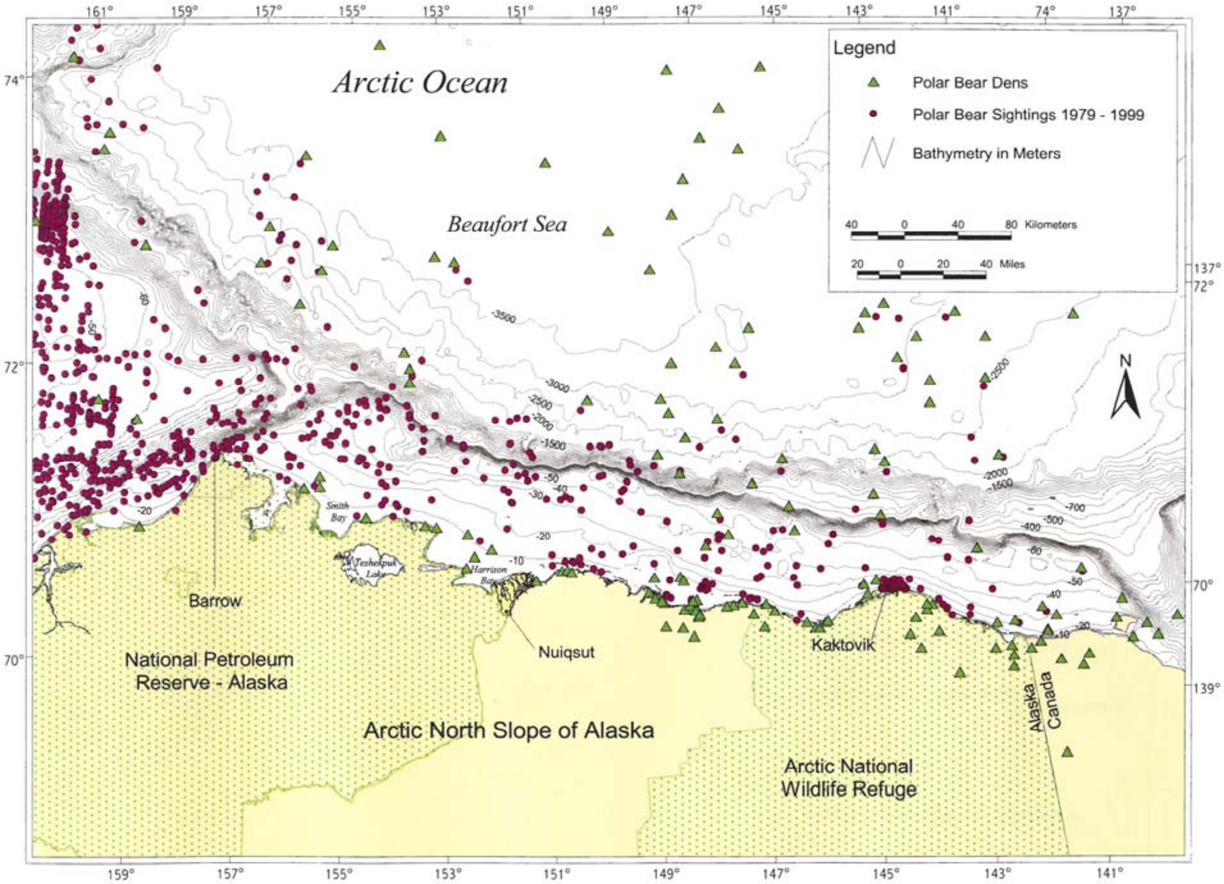
### A. Disturbance or Destruction of Essential Habitat

Scientists have identified at least two main types of essential habitat for polar bears: maternity denning areas and areas such as leads and polynyas that are key feeding areas (Lentfer 1990; FWS 1995). This section reviews impacts first on maternity denning areas and second on feeding areas.

Oil and gas exploration and development activities can impact polar bear reproduction and recruitment via disturbance of maternity denning areas (Lentfer 1990; Amstrup 2000). Experience with captive female polar bears suggests that they may be particularly sensitive to noise and disturbance during maternity denning (MMS 2003). Human scent and other noises near maternity dens also may disturb the bears (MMS 2003). Seismic-testing activities within 200 meters of the den may cause abandonment of the den (MMS 2003). If a female bear with cubs is forced to prematurely abandon a den, the survival of the cubs is likely to be low, and therefore disturbance of dens can result in reproductive failure (Amstrup 1993; MMS 2003). Polar bears may be more likely to abandon dens in the fall, when they have less to lose reproductively than in the spring (Amstrup 1993).

Oil and gas development has the highest potential to impact polar bear populations via disturbance of denning where polar bear denning is locally concentrated. In Alaska, the highest density of land dens occurs along the coast of the eastern Beaufort Sea within the Arctic National Wildlife Refuge ("Arctic Refuge") (FWS 1995). Bluffs along beaches and cut banks along rivers provide topographic relief for maternity dens dug into drifted snow (FWS 1995). Land dens are not limited to the immediate coastline. Some have occurred inland approximately 48 kilometers from shore (FWS 1995; Figure 22).

**Figure 22: Polar Bear Sightings and Dens, Beaufort Sea Region**
Source: MMS (2003:Figure II.B-3e).




Most of Alaska's Beaufort coast and the offshore region is already subject to oil and gas activities or open to development, including the area directly offshore from the Arctic Refuge. Oil and gas development is currently prohibited in the Arctic Refuge absent Congressional authorization, however, the current Administration is seeking such authorization. The NRC (2003) has estimated that the Arctic Refuge has 3.2 billion barrels of "economically recoverable reserves" – that is, the amount of oil that it would be economically feasible to produce given today's technology. Within the Arctic Refuge, oil reserves are concentrated in the 1002 Area, and, in particular, in the north-central portion of the 1002 Area (NRC 2003). Oil exploration and development in the Arctic Refuge pose a substantial threat to the Southern Beaufort Sea polar bear population.

Amstrup (1993) located 44 dens on land or land-fast ice along the mainland coast of Alaska and Canada between 1981-1992. Of those, 20 (45%) were within the bounds of the Arctic Refuge, and 15 (34%) were within the bounds of the 1002 Area (Amstrup 1993). The coasts of the Arctic Refuge and 1002 Area constitute only 13% and 10%, respectively, of the longitudinal range over which the mainland dens were observed (Amstrup 1993). More dens are located in the Arctic Refuge and the 1002 area than would be expected if polar bears denned uniformly along the coast (Amstrup 1993). In addition to the 20 dens within the Arctic Refuge, one den was on lands controlled by the village of

Kaktovik and surrounded by Arctic Refuge lands, two others were just offshore of the 1002 Area on land-fast ice, and numerous dens were also found in Canada just east of the Arctic Refuge (Amstrup 1993). Explanations for this high concentration include the quality of the habitat, proximity to favorable hunting and past human pressure along other areas of the coast (FWS 1995). While currently just over half of denning activity by the Southern Beaufort Sea population appears to be on sea ice, during one study the proportion of bears denning on land appeared to be increasing (Amstrup 2000). In this area, bears appear to be faithful to type of denning habitat, but not to precise denning locations (FWS 1995). Females that denned on land were more likely to den on land again in subsequent years, and those denning on pack ice were more likely to return to pack ice (FWS 1995).

Polar bear dens have also been found recently in the area of the proposed Liberty well development (MMS 2003). Barrier islands in shallow water along the northern and western coasts of Alaska are also important denning habitat (FWS 1995). Flaxman, Pingok, Cross, Cottle, Thetis, and other barrier islands in the Beaufort Sea are known to support maternity dens (FWS 1995). Other important denning areas in Alaska include (East of Point Barrow) the Kachiksuk Bluffs, Point Poleakoon in Smith Bay, at the mouths of the Nechelik and Kuprigruak channels of the Colville River, and the Oliktok Point area (FWS 1995). West of Point Barrow, near Wainwright, bears den along the Kuk River and tributary drainages, uplands, coastal areas and barrier islands near Icy Cape, and areas near Point Belcher (FWS 1995). Near Point Lay bears den in the Kukpowruk River drainage, coastal areas near Cape Sabine, Cape Beaufort, Cape Dyer, and Cape Thompson (FWS 1995).

Amstrup (1993) reported observations of polar bear response to aircraft and other disturbance, including forty cases of potential disruptions of denning by research aircraft. Amstrup (1993) is not a quantitative study of disturbance and related behavior, but demonstrates a variation in the behavioral response of polar bears (FWS 1995). These responses range from normal denning and emergence behavior, to possible early departure from dens, to possible increased activity levels at dens, to abandonment (FWS 1995).

Four bears in the study were exposed to unusually intense aircraft activity and displayed variable responses (Amstrup 1993). One bear was exposed to a helicopter overflight while digging a den on October 30, 1984, fled at the sound of the helicopter, was captured, instrumented, and released beside her excavation (Amstrup 1993). When this bear recovered she wandered extensively for over a month before entering a new den on December 2 (Amstrup 1993). A second bear was exposed to a helicopter hovering 100 m overhead about 100m in front of her den on November 5,1983 (Amstrup 1993). This bear ran from her den, was captured and released adjacent to her den, and then traveled up to 120 km from the first den before entering a second den 20 km from the first (Amstrup 1993). Other bears did not flee from extensive aircraft or other disturbance during the study (Amstrup 1993). Amstrup (1993) also notes that some bears in the study were observed to abandon dens in the absence of any known anthropogenic disturbance, and therefore the disturbances that were noted cannot be attributed with certainty to the human activities. Amstrup (1993:250) concluded as follows:

> Polar bears preferred to den on and near [the Arctic Refuge], and if hydrocarbon development occurs there, the potential for disturbance of denning polar bears will increase. Loss of a large portion of the present productivity of polar bears denning [in the Arctic Refuge] would undermine recruitment in the Southern Beaufort population….

Confirmed and suspected polar bear maternity dens have also been located in and near EL 420 in the Canadian Beaufort Sea (Devon Canada Corporation 2004; Figure 19 (page 94). Neither the Canadian nor the US environmental documents contain any analysis of the cumulative impacts of oil and gas development in the Canadian and US Beaufort Sea to polar bear denning or with regard to any other types of impacts to the polar bear (Devon Canada Corporation 2004; MMS 2004 and 2003).

Impacts to polar bear denning on the Beaufort coast and in the Arctic Refuge may be magnified by interactions with global warming. If the Southern Beaufort Sea population were to respond to global warming and a reduction in sea ice by denning increasingly on land, a higher proportion of the population would den in the vicinity of the Arctic Refuge. If this were to occur, the threat from oil and gas development in the Arctic Refuge to the continued survival of the Southern Beaufort Sea polar bear population would be heightened. One study has already suggested that the percentage of bears denning on land is increasing (FWS 1995; Amstrup 2000). Moreover, while the Southern Beaufort Sea population currently spends summers on the pack ice and spends little time on land but for maternity denning (FWS 1995), this population could also respond to global warming by spending the summers on land, as the Western Hudson Bay population currently does, where the bears would be exposed to high levels of disturbance from oil and gas activities. Polar bears in the Southern Beaufort Sea population will also likely come ashore in poorer condition due to the energetic and other costs of an increasing distance between the southern edge of the pack ice and land, and therefore be more vulnerable to oil and gas related impacts.

Polar bear hunting and feeding may also be impacted by oil, gas and mineral activities (Lentfer 1990). Activities such as dumping, dredging, and drilling and construction of platforms, pipelines, support facilities, and storage facilities may damage or destroy feeding areas, and cause polar bears to abandon prime habitat to use marginal habitat or to concentrate in undisturbed areas (Lentfer 1990). Conversely, construction of artificial islands may increase feeding opportunities by enabling the formation of leads on the lee side of the island and attracting ringed seals but would also increase the probability of human-bear interactions (Lentfer 1990).

Lentfer (1990) suggests a number of mitigation measures to address impacts to polar bear maternity denning and hunting and feeding areas, including deleting known denning areas and migration routes from lease sale offerings, restricting exploration and development activities in denning habitat during critical times of the year, laying seismic lines, pipelines, and roads perpendicular to and inland from the coast rather than parallel and adjacent to the coast to minimize conflict with polar bear movement routes, consulting local people on the historical importance of proposed development sites as polar bear habitat, and minimizing cumulative impacts of exploration and development activities by minimizing the area of development sprawl.

## B. Acute and Chronic Oil Spills

Because polar bears are particularly susceptible to oil spills, the expansion of oil development across the Arctic poses a serious threat. There has only been a single laboratory experiment, conducted in 1981, in which scientists directly observed the impacts of oil on polar bears. The following is excerpted from a description of the experiment, conducted on three captive bears:

> The three animals were coaxed individually along a passageway leading to a small pool containing 7000 L of seawater covered with a 1 cm surface slick of crude oil. None entered the pool voluntarily, but all three investigated its oil-covered surface. As the bears stretched out over the pool to reach seal blubber suspended inaccessibly from the top of the cage, the door was closed behind them, forcing them into the water. The

> bears made deliberate attempts to escape and were able to do so to some extent by supporting themselves on the cage bars which encircled the pool. They continued trying to obtain the bait. When the cage door was opened after 15-50 minutes, the bears left the pool immediately….
>
> During the first few hours after oiling, all three bears groomed their paws and forelegs intensively. One rubbed its coat along the cage bars, while another attempted to use snow that was provided. The snow became fouled and the bears consumed some of it. Grooming activity subsided over the next 5 days, though the bears were still covered with oil. Ingested oil caused vomiting and diarrhea. Hydrocarbons were absorbed into the circulation, distributed to various tissues, and excreted by bile and urine. During the 4 weeks after oiling, there was biochemical evidence that the bears were developing liver and kidney failure, and a disorder of red blood cell formation. Twenty-six days after oiling, one of the bears died, and 3 days later, another was euthanized.
>
> The principle findings at necropsy were degeneration of kidney tubules, low-grade liver lesions, depressed lymphoid activity, and fungus-containing ulcers in the gastrointestinal tract. This suite of pathologic changes suggests that the toxic effects of oil were compounded by the stresses of the experiment…. (St. Aubin 1990).

The experiment showed that oil will soak a polar bear's pelage and persist for several weeks where it will be groomed and ingested, irritate the skin, and destroy the insulating abilities of the fur (Lentfer 1990; Stirling 1998). The recorded fatalities occurred from physiological effects on lungs, kidneys, blood, gastrointestinal tract, and other organs and systems, even in the absence of the thermal effect (Lentfer 1990; NRC 2003; Stirling 1998). Thus, available data suggest that if oil is spilled in leads occupied by polar bears, they will become fouled (Stirling 1998), and that an oil-coated bear that is not cleaned and rehabilitated will probably die (Lentfer 1990). A polar bear facing stress such as low food availability or unusual environmental conditions would also likely be more severely impacted than a bear in optimum condition (St. Aubin 1990). Therefore, bears already in poor condition from impacts due to global warming would be at even higher risk.

Oil spilled in sea-ice habitat would likely concentrate in leads and between ice floes resulting in direct exposure of polar bears, ringed seals, and bearded seals to oil (PBSG 2005). Seal concentrations at leads where oil would also concentrate could draw polar bears to the most contaminated areas (St. Aubin 1990). In addition, several aspects of polar bear behavior increase the likelihood that they would contact spilled oil in the Arctic environment during the ice-covered period (FWS 1995). Polar bears hunt by swimming between ice floes and along leads, submerging their heads to grab seals from the leads and breathing holes (Stirling 1990; FWS 1995), and from the edge of seal breathing holes, where they reach into the water with their jaws, often submerging their heads (Stirling 1990). Because they are curious, fearless, and wide-ranging, they tend to be attracted to areas of activity and therefore possibly to the site of an oil spill (Stirling 1990; FWS 1995). Polar bears may also ingest oil when scavenging oil contaminated carcasses (Lentfer 1990; St. Aubin 1990; FWS 1995).

Polar bears are also particularly susceptible to oil contamination because grooming is an integral and important part of their behavior (Stirling 1990). Like the sea otter, the polar bear must maintain a pristine hair coat as insulation against the cold (Stirling 1990). If contaminated with oil, a polar bear will groom itself by licking its paws, and washing in water and snow, thereby ingesting the oil (Stirling 1990).

Female polar bears that den along the Alaskan Arctic coastal plain and Canadian mainland coast and in the vicinity of Herschel Island would be at the highest risk of contacting an oil spill (Stirling 1990). After leaving their dens in spring, female polar bears hunt seal pups in stable fast ice on the landward side of the sea-ice transition zone, but eventually must cross leads to reach the retreating pack ice where they spend the summer (Stirling 1990). A lead contaminated by oil would either obstruct the path of bears or contaminate those that passed through it (Stirling 1990).

Oil spills may also impact polar bears' food supply by impacting lower benthic levels, which could have cascading affects through the food chain, or by direct impacts on ringed or bearded seal populations.

Oil spills are commonplace in Alaska's Arctic. Each year between 1977 and 1999 there were an average of 234 reported spills, with an average spill volume of 537 barrels, from exploration and development activities in Alaska (NRC 2003). These spills occurred around exploration and production facilities, pipelines, and pumpstations, and from various vehicles (NRC 2003). While there has fortunately not yet been a major oil spill from an offshore production facility in the Beaufort Sea or from a ship in Arctic waters, the risk of such a spill is very real. As noted above, offshore oil production has thus far accounted for a very small percentage of the total oil production in Alaska. Each additional offshore oil development increases the risk of a large oil spill in polar bear habitat.

Fifteen years ago, Lentfer (1990) stated that the focus of mitigation measures for oil spills should be those that prevent the spill from happening in the first place, because spills in-ice covered waters may be difficult or impossible to clean up. Today, there is still no effective method for cleaning or controlling an oil spill in drifting or pack ice in Arctic waters, where difficult weather conditions are commonplace (Norris et al. 2002; DF Dickens Associates Ltd. 2004; MMS 2004). A critical deficiency is the continued inability to reliably detect and map oil trapped in, under, on, or among sea ice (DF Dickens Associates Ltd. 2004). This deficiency affects all aspects of response to spills in ice, and as yet there is no firm hope for a solution – only further research suggestions (DF Dickens Associates Ltd. 2004). The most effective oil recovery strategy for oil spills in ice-covered waters remains burning-in-place, a technique developed during the 1970s and 1980s (DF Dickens Associates Ltd. 2004). This technique is not effective for situations such as a thin film of oil among ice floes (DF Dickens Associates Ltd. 2004), and also has obvious limitations where polar bears are present. Mechanical recovery of oil spills in pack ice is limited by even very low densities of ice interrupting conventional containment and skimming activities, and improvements in mechanical equipment are unlikely to produce substantial gains in response effectiveness (DF Dickens Associates Ltd. 2004). Dispersants are used in many areas of the world, but have limited usefulness in cold water with ice, and research on improving their effectiveness in ice-covered waters is still only in the early stages (DF Dickens Associates Ltd. 2004). The toxicity of the dispersants themselves is of major concern (DF Dickens Associates Ltd. 2004), particularly with regard to polar bears.

The MMS (2003 and 2004) calculates the risk of an oil spill in the Beaufort Sea from the Beaufort Sea Multiple Lease Sale by multiplying a hypothetical spill rate times an estimated 460 billion barrels of oil that may be produced from the area.[15] The MMS uses a "best estimate" of .25 oil spills per

[15] Petitioners believe that the analysis contained in MMS (2003) and MMS (2004) is seriously flawed in that it systematically understates the risks posed by oil and gas development to the environment and to the polar bear. MMS (2003) and MMS (2004) are cited here extensively, however, because the analysis represents a minimum estimate of the risk. Throughout this

billion barrels produced, and notes a 95% confidence limit that the spill rate would not be greater than .30 oil spills per billion barrels (MMS 2004:7). This is a significant underestimate of the risk.[16] Nevertheless, the MMS still estimates an 11% chance of an oil spill larger than 1,000 barrels in the Beaufort Sea from development resulting from the Beaufort Sea Multiple Lease Sale (MMS 2004) – a significant risk indeed for polar bears.

The MMS (2003) also analyzes the possible impacts from a hypothetical 1,500-4,600 barrel oil spill in the Beaufort Sea. The analysis is subjective, and concludes, variously, that most likely 6-10 bears would be killed by such a spill, but also that if a spill occurred near where bears were concentrated feeding at whale carcasses at Cross or Barter island that 5-30 bears could be killed (MMS 2003:121). Depending on when and where the spill occurs, MMS (2003) estimates that up to 100-200 ringed seals could be directly killed. MMS (2003) also states that polar bears could be indirectly impacted by an oil spill during a heavy ice year in which the oil caused a loss of plankton and benthic invertebrates and affected the food chain, thus decreasing productivity of breeding ringed seals and impacting prey availability for the bears (MMS 2003). Over the production life of all sales in the Beaufort Sea Multiple Lease Sale, MMS (2003:IV-121) also expects 82 small crude oil spills of three barrels each, and 157-202 small refined oil spills of .7 barrels, which collectively "could be expected to have an additive effect on seal, walrus, and polar bear losses, perhaps increasing losses by a few polar bears, seals, and walrus pups and increasing habitat contamination by perhaps about 1-2%."

The MMS also briefly analyzes the impacts from an oil spill greater than 180,000 barrels (a spill 75% the size of the approximately 240,000 barrels spilled during the *Exxon Valdez* disaster of 1989). The MMS (2003) estimates that up to 128 polar bears and 2,590 ringed seals could be contaminated with oil, and that this would have a long-term impact on the Southern Beaufort Sea population.

The MMS also purports to analyze cumulative impacts to the polar bear and concludes that "(p)otential cumulative effects on…polar bear…would be of primary concern and warrant close attention and effective mitigation practices" (MMS 2004:Appendix I, Page 7). The MMS's cumulative impacts analysis vastly understates the threat to the polar bear because it does not include other reasonably foreseeable impacts, including but not limited to the Northstar production facility in the Beaufort Sea, other oil and gas development in the National Petroleum Reserve – Alaska and on state and private lands in Alaska, oil and gas development in the Mackenzie River Delta and the Canadian Beaufort Sea, and an increase in Arctic shipping as global warming decreases ice cover, all of which will substantially increase the risk of oil spills in polar bear habitat. For the Northstar project alone, FWS models demonstrated that up to 78 bears could be killed by a spill in open water, and up to 108 bears by a spill in broken ice conditions (FWS 2003). Overall, the FWS estimated a .4- 1.3% chance that an oil spill would result in the death of one or more bears during the 16-month period following the issuance of incidental take authority for Northstar (FWS 2003). The likelihood of an oil spill increases with the time period considered. The MMS also does not consider events that it considers unlikely, such as two oil spills or other disturbance factors occurring at the same time that would magnify impacts

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section we also point out a few of the major ways in which MMS (2003) and MMS (2004) underrepresent the threats posed by oil and gas development.

[16] The MMS also notes that the confidence interval would increase if certain variability from baseline data on spill statistics in other areas used to derive this estimate were included (MMS 2004). The spill rate used by MMS (2003 and 2004) is also an underestimate because it relies upon an industry study (Bercha Group Inc. 2002) that downgrades the spill probability based on engineering "judgments" for unique Arctic factors such as ice gouging, permafrost, and ice force. In this way, it has relied on arbitrary information to lower the numerical probabilities for a major spill, resulting in the conclusion that there is a low risk of significant impacts to various resources.

(MMS 2003). These cumulative impacts pose a significant threat to the continued survival of the Southern Beaufort Sea polar bear population.

The MMS includes a one-paragraph summary of the impacts of global warming on polar bears. Despite concluding that "potential cumulative effects on polar bears, seals, and other i[c]e-dependent pinnipeds would be of primary concern and would warrant close attention and effective [mitigation] practices" (MMS 2004:Appendix I, Page 7), the MMS did not include any effective mitigation practices for the polar bear in its approval of Lease Sales 186 or 195, and the MMS itself admits that there is no effective method of cleaning up oil spilled in broken ice conditions (MMS 2004). Moreover, the MMS has no method for analyzing the combined impacts of climate change and the massive oil and gas development it is authorizing:

> While there is considerable information that global warming has affected the Arctic over the past several decades, there is not agreement that global warming will continue at the same rate into the future. In the cumulative assessment, we are considering what would occur in the future. There are researchers and information that dispute whether climate change will continue along the current trend into the future; hence, MMS has chosen to consider that information speculative. However, we include a brief analysis of climate change in Appendix I (MMS 2004:59).

As discussed above, climate change is not speculative, and all climate models predict future warming in the Arctic – it is only the rate of change that varies. The MMS's authorization of large-scale oil and gas development in polar bear habitat without adequate analysis or mitigation of impacts to the polar bear is a substantial threat to the species.

Environmental review of the Canadian EL 420 project in the Southern Beaufort Sea contains only the cursory statement that polar bears could be killed and injured by contact with spilled hydrocarbons (Devon Canada Corporation 2004). Like the US environmental documents, the Canadian analysis does not discuss the cumulative risk of oil spills from Canadian and US activities (Devon Canada Corporation 2004).

Though oil production in the Barents Sea is just beginning in Norway, there have been a "relatively large" number of "acute" oil spills from Norwegian offshore installations (Andresen and Gooderham 2004:25). As recently as May 2003, approximately 4,700 barrels of oil were discharged from the Draugen field in the Norwegian Sea (Andresen and Gooderham 2004). Between five and 25 acute oil spills of over 7.5 barrels occurred each year from 1990 to 2002 in Norwegian waters (Andresen and Gooderham 2004).

Tapped out and abandoned oil production sites also pose a risk of contamination to the environment and to polar bears. This risk is exacerbated by the industry practice of larger companies selling out to smaller companies as production sites age and become economically marginal (NRC 2003). This trend has already begun in Cook Inlet in Alaska where oil production began prior to 1969 (NRC 2003), and may occur in polar bear habitat as well as existing oil fields age. Smaller companies are less likely to have the resources to conduct restoration when production ceases, and the NRC (2003:95) reports that existing bonding requirements are "not remotely sufficient" to cover the costs of restoration.

Despite major disasters such as the 1989 *Exxon Valdez* tanker spill, neither spill prevention nor emergency response appear to have advanced substantially over the past several decades. Oil and gas development continues to proliferate, especially in the American Arctic, but offshore of Canada, Norway, Greenland, and Russia as well, without adequate avoidance or mitigation strategies for the polar bear. Based on the polar bear's vulnerability to oil and the extreme conditions in the Arctic including pack ice, the risk to polar bears from oil spills as oil development and shipping increase is very substantial.

### C. Acute and Chronic Spills of Other Toxic Substances

Other toxic substances associated with oil, gas, and mineral development also threaten polar bears. In 1988, one polar bear was discovered to have died after ingesting a substance including ethylene glycol and Rhodamine B dye (Lentfer 1990). Ethylene glycol is extremely toxic – a dose of approximately one liter may be fatal to a polar bear – and its sweet taste may encourage consumption (Lentfer 1990). This particular bear was located only because it was wearing a radio collar, demonstrating that other bears may die in a similar way but never be discovered (Lentfer 1990). Other items such as Styrofoam, pieces of plastic, and parts of a car battery, which apparently killed the bear, have all been found in polar bear stomachs (Stirling 1990). Native hunters have also reported observing bears biting cans of snowmobile oil and neoprene fuel bladders (Stirling 1990). The scale of the threat from ingestion of toxic substances will increase as oil and gas activity and other human activities continue to expand in the Arctic.

In Alaska, hazardous waste produced by the oil and gas industry is exempt from regulation under the Resource Conservation and Recovery Act, one of the United States' primary statutes for the regulation of toxic substances (NRC 2003). Therefore, these substances are unregulated regardless of whether they would otherwise meet the U.S. Environmental Protection Agency's criteria for hazardous-waste classification (NRC 2003). Most such waste is injected into subsurface formations (NRC 2003). Because these substances are unregulated, the total quantity produced is unknown (NRC 2003).

Exempt hazardous and potentially hazardous waste includes all produced fluids, muds, and associated wastes that have circulated in the oil well, as well as solids and ligands that originated in the well, such as formation water (NRC 2003).

The volume of "produced water" gives some context for the scale of wastes produced in Alaska's Arctic oil fields. Produced water comes to the surface with oil and gas and must be removed before the oil can be sent to the Trans-Alaska Pipeline (NRC 2003). In 1998 approximately 1.23 million barrels of produced water was generated <u>per day</u>, similar to the amount of oil produced (NRC 2003). Most produced water is treated and re-injected into the reservoir; some is injected into approved disposal wells (NRC 2003). The volume of associated wastes at the Prudhoe Bay field is approximately 1 million barrels (159 million liters, or 42 million gallons) per year. More than 1.5 billion barrels (238 billion liters, or 63 billion gallons) of produced water and associated wastes have been pumped into subsurface disposal formations (NRC 2003).

Until recently, waste materials from well drilling, including muds and cuttings, crude oil, spill materials, and other substances were disposed of in open gravel-bermed areas called reserve pits that typically contained up to 51 million liters of waste (NRC 2003). Reserve pits created many pollution problems, including leaching of contents to the surrounding tundra and significant impacts on water quality in nearby ponds (NRC 2003). Fluids that accumulated in the pits were typically poured directly on the tundra or sprayed on dirt roads to ameliorate dust problems (NRC 2003). A settlement of legal claims brought by conservation organizations requires most of the old reserve pits in the Iuparuk and Prudhoe Bay fields to be cleaned out and the waste ground and injected into subsurface formations (NRC 2003). The largest grinding and injection plant in the world now operates on Alaska's Arctic Slope, and injected approximately 332,000 $m^3$ of reserve-pit solids in the year 2000 alone (NRC 2003). One hundred and eighty-four of the 328 reserve pits on Alaska's Arctic Slope are now officially closed, but this does not necessarily mean that the sites have been restored (NRC 2003): they still pose a risk of contamination of the environment and to the polar bear.

Safe disposal via the injection method requires that porous, water-bearing formations below the surface casing accept fluids at pressures that will not propagate fractures through the upper confining zones (NRC 2003). The disposal fluids must be compatible with the formation water, which cannot then be used as a source of drinking water (NRC 2003). While the injection method appears environmentally superior, and appears to decrease the potential for polar bears to contact hazardous waste from oil and gas activities, it is not without problems. In 1998 Doyon Drilling, a subcontractor to BP, pled guilty to illegally injecting hazardous waste back into groundwater (Trustees for Alaska 1998). The wastes eventually reached the surface and the surrounding Beaufort Sea (Trustees for Alaska 1998). The violations occurred at the Endicott oil facility, which some have called a model of how drilling should proceed in the Alaska Refuge (Trustees for Alaska 1998), demonstrating that even the most technologically advanced and "environmentally sensitive" oil and gas development poses a serious risk to polar bears.

A related problem is the erosion of the steep permafrost bluffs behind the narrow beaches of the Beaufort and Chukchi Seas (NRC 2003). In some areas, the bluffs have been retreating by an average of 2.5 m (8 ft) per year, making them the most rapidly retreating shoreline in the US (NRC 2003). This severe erosion presents a potential risk from toxic-waste pits abandoned during earlier coastal exploratory drilling, and also for pipelines and other facilities that cross the shoreline (NRC 2003).

In Canada, drilling muds and cuttings, as well as other fluids and solids will be discharged into seawater, and may impact marine mammals including the polar bear (Devon Canada Corporation 2004).

Norway has set a "zero discharge" goal of oil and gas related chemicals to the sea by 2005, and projects that the petroleum industry is close to meeting this goal (Andresen and Gooderham 2004). The percentage of chemicals used during production that is discharged directly to the sea has declined from 64% in 1989 to 30.4% in 2002 (Andresen and Gooderham 2004), but discharges are still occurring.

### D. Attraction to and Disturbance by Industrial Noise and Harassment by Aircraft, Ships, and Other Vehicles[17]

Noise generated by seismic exploration, road construction and traffic, helicopters, fixed-wing aircraft, ships, and over-land vehicles may interfere with polar bear feeding, breeding, and denning activity, stress individuals, and alter the distribution of polar bears and polar bear prey (Lentfer 1990).

Polar bears will be impacted by air and marine traffic associated with exploration activities for the Beaufort Sea Multiple Lease Sale (MMS 2003). Ringed seal pupping in floating-shorefast-ice habitats within about 150 meters (490 feet) of the on-ice shot lines for seismic surveys, and female polar bears denning within one mile of the shot lines could be disturbed by seismic surveys (MMS 2003). Air

[17] Impacts on maternity denning from oil and gas associated noise is discussed beginning on page 97.

and marine traffic and seismic surveys could also produce "startle responses" in both polar bears and ringed seals (MMS 2003). During development of the Beaufort Sea Multiple Lease Sale oil fields, 280 square miles of open-water shallow-hazard survey lines at survey sites, using one or two seismic vessels for 7 days, could disturb seals and polar bears (MMS 2003). The zone of influence is estimated as the area where the noise level exceeds 160 decibels – as much as 4.9 kilometers from the seismic vessel (MMS 2003).

Artificial islands and dredging and drilling operations are major sources of airborne noise from oil and gas production activities (MMS 2003). These noises could disturb hauled-out seals and polar bears within a few kilometers of the noise source (MMS 2003). Underwater noise generated by support vessels, icebreakers, seismic boats, and aircraft as well as dredges, drill rigs, drillshops, and offshore-production and processing facilities can displace ringed seals from important denning and pupping habitats (MMS 2003). Air traffic is required to maintain a buffer between marine mammal populations when weather permits, however, visibility conditions frequently result in low-flying aircraft which disturb animals (MMS 2003).

In Canada, the EL 420 project will also generate noise that may disturb polar bears (Devon Canada Corporation 2004), as will oil and gas development offshore of Norway, Greenland, and Russia.

### E. Death, Injury, or Harassment from Interactions with Humans[18]

Increasing industrialization of the Arctic brings increases interaction between polar bears and humans. Such interaction often proves fatal to the bear. Since 1968, two bears have been reported killed in the US as a result of encounters with oil and gas industry personnel **(**FWS 2003). Between 1976 and 1986, 33 polar bears were killed in the Canadian Northwest Territories as a result of such encounters (FWS 2003). Between 1994 and 2000, 258 polar bear sightings were recorded by the oil and gas industry as required by incidental take regulations issued by the FWS pursuant to the US MMPA (FWS 2003). During this period, polar bears were sighted during 32 of the 115 activities covered by incidental take regulations (FWS 2003). Approximately two-thirds of the sightings (171 of 258) occurred during production activities, revealing that oil and gas activities that occur on or near the Beaufort Sea coast have a greater possibility of encountering polar bears than activities elsewhere (FWS 2003). Sixty-one percent of polar bear sightings (157 of 258) consisted of observations of polar bears traveling through or resting near the monitored areas without a perceived reaction to human presence, while 101 polar bears sightings involved bear-human interactions. Twenty-one percent of all bear-human interactions (21 of 101) involved anthropogenic attractants, such as garbage dumpsters and landfills, where these attractants altered the bear's behavior (FWS 2003). Sixty-five percent of bear-human interactions (66 of 101) involved Level B harassment as defined by the MMPA (see page 135 for further discussion of harassment and the MMPA (FWS 2003).)

The MMS (2003) predicts that up to 10 bears will be killed as a result of increased interactions due to the Beaufort Sea Multiple Lease Sale, though the method for calculating this number is not disclosed.

In Canada, Norway, Greenland, and Russia, expanding oil and gas development will increase the risk of death or injury to polar bears during interactions with humans.

[18] Further discussion of the threats posed by human-bear interactions begins on page 52, below. This section covers issues specific to oil and gas development.

### G. Effects of Scientific Research on Impacts from and Responses to Oil Spills and Other Impacts

Scientific research has been critical for the scientific and management community to respond to polar bear conservation issues, and generally should not be viewed as a threat to polar bears. Lentfer (1990) includes oil and gas industry research as a potential threat. For example, field trials of oil spill response in the Arctic could go awry and cause an oil spill which injured or killed polar bears. To date, full-scale field trials have not been held in the Arctic, but are strongly recommended by at least one consultant (DF Dickens Associates Ltd. 2004).

# Appendix C: The Impacts of Hunting on Polar Bears

The genesis of international polar bear conservation efforts was the response to severe overhunting of some polar bear populations in the 1950s and 1960s. The response of the international scientific and management community to successfully control this overhunting is widely regarded as one of the great wildlife management success stories. Scientific bodies such as the PBSG, which play a central role in international conservation of the polar bear and calculation of harvest limits today, had their origins during this time. Today there is extensive regulation and monitoring of polar bear hunting. For example, subsistence hunting of polar bears by Alaska Natives is considered sustainable and well managed. Despite these important past successes, however, overhunting, including illegal poaching, currently poses a threat to nearly half of all polar bear populations.

Until very recently, scientists and managers estimated the recent annual worldwide harvest of polar bears at between 500 and 700 bears, or approximately 2-3% of the world population of 22,000 bears (PBSG 2005). Until recently, a minority of polar bear populations were suffering from overharvest, while hunting in the majority was managed sustainably. In January, 2005, the Government of Nunavut, where a large percentage of the world's polar bear hunting occurs, announced that it was increasing overall hunting quotas for Nunavut by over 20% (Government of Nunavut 2005). These increases could lead to substantial overharvest of at least half a dozen additional populations within Canada and shared between Canada and Greenland, if all or most of the quota is taken each year. The increased harvest is of particular concern because global warming will decrease the sustainable harvest of these populations. Changes in survival rates, age of maturity, or reproductive rates can change sustainable harvest rates (Derocher et al. 2004). New inventory methods may be needed, and close monitoring is necessary to prevent amplified impacts from hunting and global warming (Derocher et al. 2004).

As detailed below, many polar bear populations now face a threat from either illegal poaching or from harvest quotas that may be set too high.

## I. BIOLOGICAL PARAMETERS

The polar bear is a classic K-selected species, where K is the carrying capacity and the population produces its maximum sustained yield ("MSY") at some level below K (Amstrup 2000). When the population is below the carrying capacity, it will respond with heightened rates of reproduction and recruitment (Amstrup 2000). The magnitude of the response determines the sustainable yield, or the proportion of the population that can be removed by humans without causing a continuing population decline (Amstrup 2000).

Because polar bears have low reproductive output, the sustainable polar bear harvest is lower than for other hunted mammals, such as deer (Amstrup 2000). For the polar bear, the total number of young produced by a population at K is nearly as numerous as the total number produced at MSY (Amstrup 2000). This also means that recovery of a population following over hunting or other impacts will be slow (Amstrup 2000). Polar bear populations pushed below MSY can become unstable because of stochastic process such as fluctuations in sea ice and ringed seal availability (Amstrup 2000). The risk of destabilizing a population pushed below MSY and the long recovery period necessary mean that the polar bear is particularly vulnerable to overharvest (Amstrup 2000). Polar bears are also very susceptible to overharvest because their life history is dependent on constantly high adult survival (Taylor et al. 1987).

## II. HISTORICAL IMPACTS FROM AND RESPONSES TO HUNTING

Indigenous people of the Arctic have hunted polar bears for thousands of years (Stirling 1998). Unlimited hunting of polar bears with stone age technology did not pose a threat to the species (Stirling 1998). With the advent of firearms and new transportation methods, and increasing exploration and settlement of the Arctic by Europeans and North Americans in the eighteenth, nineteenth, and early twentieth centuries, hunting increased dramatically (Stirling 1998). For centuries, foreign visitors to the Arctic killed as many polar bears as possible (Amstrup 2003). More than 150,000 polar bears may have been killed or captured in Eurasia since the beginning of the eighteenth century (Stirling 1998).

Polar bears historically occurred on St. Matthew Island, over 350 km south of the Bering Strait, but were eliminated by commercial hunters in the early 1900s (Amstrup 2003). Overwintering commercial whalers, along with local residents, may also have nearly eliminated the bears that once denned along the north coast of Alaska (Amstrup 2003).

Unsustainable hunting of polar bears became a major conservation concern in the 1950s and the 1960's due in large part to the increasing use of snow machines (Stirling 1998). Public outrage was sparked in particular over airborne polar bear hunting in Alaska (Stirling 1998). Bears were also shot by tourists on Norwegian tour ships near Svalbard (Stirling 1998). In addition, Norwegian trappers used unmanned set guns rigged to shoot the bear when it pulled on bait (Stirling 1998). There was a widespread perception that polar bear hunting during this time was unsustainable.

International concern regarding overharvest of polar bears led to the first international meeting of all five countries with polar bear populations, and ultimately to the International Agreement on Polar Bear Conservation in 1973 (Stirling 1998). The scientific body that is now the PBSG was also first formed at this time (Stirling 1998). In the interim between the first meeting and the signing of the International Agreement, individual countries also implemented various measures to control hunting, including a temporary quota system in Canada, introduction of bag limits in Alaska, and a prohibition on the shooting of mothers and cubs in Svalbard (Stirling 1998). Following these measures, adult polar bear survival increased and most populations rebounded. However, polar bears have not returned to denning on St. Matthew Island.

## III. CURRENT MANAGEMENT AND HARVEST LEVELS

The PBSG meets every three to five years and reviews current data on all aspects of polar bear science and management. The PBSG most recently published worldwide polar bear harvest statistics and estimates of sustainable harvest in 2001 (Lunn et al. 2002(a); Table 12 (next page)). As of 2001, most polar bear populations were harvested below, at, or near sustainable levels (Lunn et al. 2002(a); Table 12), though overharvest was apparent in the M'Clintock Channel population and Gulf of Boothia population, and strongly suspected in the Chukchi Sea Population. In January, 2005 the Government of Nunavut announced an increase in overall harvest quota for Nunavut from 403 to 518 bears, an increase of 115 polar bears, or over 28% (Table 11 (next page)).

**Table 11: Increases in Nunavut Polar Bear Harvest Quotas**
Source: Adapted from Government of Nunavut (2005).

| Population | Previous Base Quota | New Quota | Change |
|---|---|---|---|
| **Northern Beaufort** | 6 | 6 | No change |
| **Viscount Melville** | 2 | 3 | +1 |
| **M'Clintock Channel** | 0 | 3 | +3 |
| **Gulf of Boothia** | 41 | 74 | +33 |
| **Lancaster Sound** | 78 | 85 | +7 |
| **Norwegian Bay** | 4 | 4 | No change |
| **Kane Basin** | 5 | 5 | No change |
| **Baffin Bay** | 64 | 105 | +41 |
| **Davis Strait** | 34 | 46 | +12 |
| **Western Hudson Bay** | 47 | 56 | +9 |
| **Southern Hudson Bay** | 25 | 25 | No change |
| **Foxe Basin** | 97 | 106 | +9 |
| **NUNAVUT TOTAL** | **403** | **513** | **+115** |

In Table 12, we calculate the likely harvest of polar bears by adding the mean annual harvest for each population reported by Lunn et al. (2002a:22) to the increases in the quotas for each population announced by Nunavut in January 2005. This is by necessity a rough estimate, because data on actual harvest levels in recent years have not yet been published. Nevertheless, this estimate demonstrates that if Nunavut hunters kill the full number of bears allocated by the new quota, overhunting poses a potential threat to at least half of all polar bear populations. The PBSG will meet next in June, 2005, and more recent data on harvest levels will almost certainly become available following that meeting. We will update the information on the threat posed by hunting as appropriate at that time.

**Table 12: Harvest of Polar Bears**
Source: Adapted from Lunn et al. (2002a:22) and Government of Nunavut (2005).

| Population | Abundance Estimate[1] | Sustainable Harvest[2] | Mean Annual Harvest[3] | Nunavut 2005 Quota Increase[4] | Estimated Future Annual Harvest[5] |
|---|---|---|---|---|---|
| **East Greenland** | 2000 | Unknown | 80 | n/a | 80 |
| **Barents Sea** | 2000-5000 | n/a | Norway-2<br>Russia-? | n/a | 2 + Unknown |
| **Kara Sea** | Unknown | n/a | Unknown | n/a | Unknown |
| **Laptev Sea** | 800-1200 | n/a | Unknown | n/a | Unknown |
| **Chukchi Sea*** | 2000+ | 86+ | US-76<br>Russia-? | n/a | 76 + Unknown |
| **Southern Beaufort Sea** | 1800 | 81 | 50 | n/a | 50 |
| **Northern Beaufort Sea** | 1200 | 54 | 32 | 0 | 32 |
| **Queen Elizabeth** | 200 | 9? | 0 | n/a | 0 |
| **Viscount Melville Sound*** | 230 | 4 | 4 | 1 | 5 |
| **Norwegian Bay** | 100 | 4 | 4 | 0 | 4 |
| **Lancaster Sound*** | 1700 | 77 | 76 | 7 | 83 |
| **M'Clintock Channel[6]*** | 350 | 11 | 24 | 3 | 3 |

| Population | Abundance Estimate[1] | Sustainable Harvest[2] | Mean Annual Harvest[3] | Nunavut 2005 Quota Increase[4] | Estimated Future Annual Harvest[5] |
|---|---|---|---|---|---|
| **Gulf of Boothia*** | 900 | 34 | 37 | 33 | 70 |
| **Foxe Basin*** | 2300 | 97 | 90 | 9 | 99 |
| **Western Hudson Bay*** | 1200 | 52 | 49 | 9 | 58 |
| **Southern Hudson Bay*** | 1000 | 41 | 45 | 0 | 45 |
| **Kane Basin*** | 200 | 9 | 10 | 0 | 10 |
| **Baffin Bay*** | 2200 | 93 | 139 | 41 | 180 |
| **Davis Strait** | 1400 | 56 | 63 | 12 | 75 |
| **Arctic Basin** | Unknown | n/a | n/a | n/a | n/a |

[1]As reported by Lunn et al. (2002a:22).
[2] As reported by Lunn et al. (2002a:22).
[3] As reported by Lunn et al. (2002a:22), calculation as of 2001.
[4] As reported by Government of Nunavut (2005).
[5] Calculated by adding the Mean Annual Harvest to the Nunavut 2005 Quota Increase where applicable.
[6] Because a hunting moratorium was implemented in the M'Clintock Channel after 2001, the likely harvest for this population is calculated as 0 +3, rather than as the mean annual kill in 2001 plus the quota increase.
* Known or potential overharvest.

The threat of unsustainable harvest in at least ten polar bear populations is of particular concern because global warming will exacerbate the impact of overhunting on polar bear populations. Global warming's impact on adult body condition and reproductive rates has already been documented in the Western Hudson Bay population and these impacts will be replicated in other populations (to the degree they are not already occurring but undocumented) as global warming progresses. Global warming will lead to changes in survival rates, age of maturity, and reproductive rates. Changes in these factors can in turn change sustainable harvest rates (Derocher et al. 2004). Despite the fact that population modeling and calculation of sustainable harvest in polar bear populations have evolved rapidly and are constantly refined by experts, new inventory methods may be needed to address amplified impacts from hunting and global warming (Derocher et al. 2004).

The threat from overharvest is of particular concern because harvest of polar bears should be managed more conservatively now than in the past due to the increasing impacts of global warming. Already half of the 20 polar bear populations globally are threatened by overharvest. Populations that are not currently overharvested may become so in the near future when global warming affects parameters such as survival and reproductive rates that determine sustainable harvest rates.

Additional information on the regulation and status of polar bear harvest in each of the five countries is summarized below.

### A. United States-Russia and United States-Canada Populations

The primary concern for U.S. populations is an illegal, possibly quite large, and unsustainable harvest of the Chukchi/Bering Sea population in Chukotka. Legal harvest in the Alaska portion of the Chukchi/Bering Sea population and in Alaska and Canada of the Southern Beaufort Sea appears to be sustainable. Information on hunting in these two populations is reviewed below.

Polar bears in Alaska have been killed historically for subsistence, handicrafts, and recreation (Angliss and Lodge 2004). The estimated annual statewide harvest [for both the Bering/Chukchi Sea population and the Southern Beaufort population] for 1925-1953 averaged 120 bears, based on the number of skins shipped from the state, that were taken primarily by Native hunters (Angliss and Lodge 2004). Between 1951 and 1972, recreational airborne hunting was popular, increasing annual statewide harvest to 150 during the 1951-60 period and to 260 during 1960-72 (Angliss and Lodge 2004). Aerial hunting by non-Natives was prohibited in 1972, which reduced the mean annual statewide harvest to 105 for the period 1980-2001 (SD=53; range 41-297) (Angliss and Lodge 2004). From 1980-2001, harvest from the Chukchi/Bering Sea population accounted for 66% of the reported annual statewide kill (Angliss and Lodge 2004).

### *1. Chukchi/Bering Seas Population*

Russia prohibited all hunting of polar bears in 1956, yet illegal poaching in Russia likely now poses a serious threat to the Chukchi Sea population. Prior to 1986, only approximately 3-5 bears were removed each year for placement in zoos (Angliss and Lodge 2004). No bears were taken for zoos or circuses from 1993 to 1995 (Angliss and Lodge 2004). Occurrence of increased "problem bear" take was first acknowledged in 1992, and one author estimated that 10 "problem bears" were taken annually (Angliss and Lodge 2004). Illegal hunting has also increased, perhaps dramatically, in response to factors such as decentralization of management authority, entering a free market economy, and increased economic pressures (Angliss and Lodge 2004). Due to lack of funding and enforcement there is nothing to stop it (Amstrup 2003).

As many as 200-400 bears may be killed each year in Chukotka (Angliss and Lodge 2004; Marine Mammal Commission 2004), and the level of poaching appears to be increasing (Amstrup 2000). While the exact number of bears killed is not known, large numbers of polar bear hides are listed for sale in Russia over the internet (Marine Mammal Commission 2004). Initial population modeling conducted by the FWS (based on preliminary data) indicate than an annual harvest of 180 bears from the Chukchi Sea population is unsustainable and projects that such take would result in a 50 percent decline in the population's abundance within 18 years (Marine Mammal Commission 2004). Russian scientists state "[d]espite a lack of sound information on the level of polar bear poaching in Chukotka it is necessary to undertake urgent special measures for the control and protection of the Alaska-Chukotka polar bear populations" (Belikov et al. 2002:87).

The majority of denning of the Chukchi Sea population occurs in Russia, in particular at Wrangel and Herald Islands and on the northern coast of the Chukotka Peninsula (Belikov and Boltunov 1998), and therefore the illegal harvest there is cause for even greater concern. "Because adult female polar bears appear to show fidelity to maternity denning areas (Ramsay and Stirling, 1990), they form locally stable populations that are highly vulnerable to extirpation if they are hunted there" (Stirling 2002:67). Moreover, Russia controls nearly half of the world's Arctic habitat, and therefore uncontrolled polar bear poaching over a broad area in Russia could have far-reaching implications (Amstrup 2003).

Recently, Alaskan Native harvest from the Chukchi/Bering Sea population has been declining (Angliss and Lodge 2004). The 1996-2000 mean harvest was 44.8 bears and the sex ratio was 64M:36F (Angliss and Lodge 2004). The decline in the Alaskan harvest may be due to a reduction in population size from the illegal harvest in Chukotka, due to altered polar bear distribution and accessibility from weather and ice conditions, or due to changes in demographics of Native hunting communities that result in less hunting of polar bears (Schliebe et al. 2002).

Due to the lack of a reliable population estimate, potential biological removal cannot be estimated for this population, and managers have "a lack of information indicating that subsistence hunting in Alaska is or is not adversely affecting this population stock" (Angliss and Lodge 2004:198).

In western Alaska, there is currently no local or government control on the number of bears taken; providing the population is not depleted [in which case harvest could be restricted pursuant to the Marine Mammal Protection Act] and the taking is not wasteful (Angliss and Lodge 2004). On October 16, 2000, the governments of the U.S. and Russia signed the "Agreement on the Conservation and Management of the Alaska-Chukotka Polar Bear Population," which will provide for harvest guidelines and quotas once it is implemented (Schliebe et al. 2002; Angliss and Lodge 2004). Native people of Alaska and Chukotka will play a central role in implementing this treaty, which was developed in large part by the Alaska Nanuuq Commission (Angliss and Lodge 2004).

The Agreement specifies that subsistence taking by Native residents of Alaska and Chukotka will be the only allowable consumptive use of polar bears (Marine Mammal Commission 2004). A joint commission composed of four members, and a government official and a representative of the native people from each jurisdiction, will establish annual taking limits that may not exceed the sustainable harvest level determined for the stock (Marine Mammal Commission 2004). The allowable take will be divided equally between the jurisdictions, though portions may be transferred by agreement (Marine Mammal Commission 2004). A scientific working group will also be established to assist in setting the sustainable harvest level (Marine Mammal Commission 2004). Other provisions prohibit the taking of denning bears, females with cubs, or cubs less than one year old, and the use of aircraft and large motorized vessels for hunting polar bears (Marine Mammal Commission 2004). The Agreement also directs the parties to undertake all efforts necessary to conserve polar bear habitats, particularly denning areas and those areas where polar bears concentrate to feed or migrate (Marine Mammal Commission 2004). It remains to be seen whether this treaty will lead to effective control of illegal harvest in Russia.

#### *2. Southern Beaufort Sea Population*

Recognition that polar bears in the Southern Beaufort Sea population are shared by residents of Canada and Alaska prompted development of the "Polar Bear Management Agreement for the Southern Beaufort Sea" ("Agreement") (Lunn et al. 2002a). The Agreement, between the Inupiat hunters of Alaska and the Inuvialuit hunters of Canada, included provisions to protect bears in dens and females with cubs, stated that the annual sustainable harvest from the Southern Beaufort Sea polar bear population would be shared between the two jurisdictions, and required the annual review of harvest levels (Lunn et al. 2002a). A principal assumption of the Agreement was that polar bears harvested within the region identified came from a single Southern Beaufort Sea population which numbered approximately 1800 bears (Lunn et al. 2002a).

Since the initiation of this local user agreement in 1988, the combined Alaska/Canada mean harvest from this stock has been 55.1 bears per year. Potential biological removal is 59, and adjusted potential biological removal level [adjusted upward because of a 2M:1F harvest ratio] is 88 (Angliss and Lodge 2004). Between 1995-2000, the average Alaska harvest for this population was 32.2 bears with a sex ratio of 71M:20F (Angliss and Lodge 2004). The Alaska quota under the agreement is 40 bears (Schliebe et al. 2002). The harvest in Canada is regulated by a quota system (Angliss and Lodge 2004). There is no further regulation in Alaska as long as the population is not listed as depleted under the Marine Mammal Protection Act (Angliss and Lodge 2004).

### B. Canadian Populations

Polar bear populations in Canada are managed by the federal government, three territories – Nunavut, Northwest Territories, and the Yukon Territory, and four provinces – Manitoba, Newfoundland and Labrador, Ontario, and Québec, which are collectively represented by the Federal-Provincial Technical Committee for Polar Bear Research ("PBTC") and the Federal-Provincial Administrative Committee for Polar Bear Research ("PBAC") (Lunn et al. 2002b). Native Land Claims have resulted in Co-Management Boards for most of Canada's polar bear populations (FWS 2001). Representatives of the Inuvialuit Game Council ("IGC"), Nunavut Wildlife Management Board ("NWMB"), Makivik Corporation and the Labrador Inuit Association have also been invited to be members of the PBTC and PBAC (Lunn et al. 2002b).

The status of polar bears in Canada is determined by the number of individuals in each population, the rates of birth and death, and the rate at which bears are harvested (Lunn et al. 2002b). The quota of bears taken by each jurisdiction is based on recommendations by the Federal-Provincial Committees. In recent years, combined polar bears quotas in Canada have exceeded 600 bears for all populations in Canada, though overall the combined quota has not been exceeded in any recent year for which data are available (Lunn et al. 2002b; Table 13).

**Table 13: Quotas[1] and Known Numbers of Polar Bears Killed[2] in Canada, 1996-97 through 1999-2000**

Source: Lunn et al. (2002b:46).

| | Man.[3] | Nfld. | NW Terr.[3] | Nunavut[4] | Ont.[5] | Qué.[6] | Yukon[7] | Total |
|---|---|---|---|---|---|---|---|---|
| **1996-97 Quota** | 8 | 4 | 525 | - | 30 | 62 | 6 | 635 |
| Killed | 7 | 5 | 467 | - | 2 | 47 | 1 | 529 |
| Captured/zoos | 2 | 0 | 0 | - | 0 | 0 | 0 | 2 |
| | | | | | | | | |
| **1997-98 Quota** | 8 | 4 | 503 | - | 30 | 62 | 6 | 613 |
| Killed | 8 | 6 | 416 | - | 8 | 33 | 0 | 471 |
| Captured/zoos | 0 | 0 | 0 | - | 0 | 0 | 0 | 0 |
| | | | | | | | | |
| **1998-99 Quota** | 8 | 6 | 93 | 404 | 30 | 62 | 6 | 609 |
| Killed | 1 | 5 | 61 | 376 | 3 | 36 | 0 | 482 |
| Captured/zoos | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | |
| **1999-00 Quota** | 8 | 6 | 93 | 419 | 30 | 62 | 6 | 624 |
| Killed | 5 | 7 | 57 | 405 | 3 | 53 | 0 | 530 |
| Captured/zoos | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | |
| **2000-01 Quota** | 8 | 6 | 97 | 395 | 30 | 62 | 6 | 604 |

[1] Management year extends from 1 July to 30 June the following year. Numbers may change as more information is received from the communities

[2] All known kills, including quota and sport-hunt kills, problem kills, illegal kills, and bears that die while being handled by scientists

[3] Through the end of the 1997-98 season, 19 of the Manitoba quota of 27 for the Western Hudson Bay population were administered by the NWT and all kills under this loaned quota included in the NWT total. Nunavut began reporting this loaned quota in their summaries in 1998/99

[4] On 1 April 1999, two independent jurisdictions were created from the former Northwest Territories: Nunavut and Northwest Territories. Nunavut began reporting quotas and harvest statistics in 1998/99

[5] Permissible kill

[6] The total allowable kill in Québec is controlled through agreements with Natives; length of hunting season is adjusted and only certain sex and age categories can be taken

[7] Yukon quota is administered by the NWT but kills are included in the Yukon total

Under the U.S. Marine Mammal Protection Act, polar bears killed in Canada may only be imported from populations approved by the U.S. Fish and Wildlife Service ("FWS"). In order to add a population to the approved list, the FWS must make findings including the following: (a) Canada has a sport-hunting program that allows the FWS to determine before import that each polar bear was legally taken; (b) Canada has a monitored and enforced program that is consistent with the purposes of the 1973 International Agreement on the Conservation of Polar Bears; (c) Canada has a sport hunting program that is based on scientifically sound quotas ensuring the maintenance of the affected population stock at a sustainable level for certain populations; and (d) the export of sport-hunted trophies from Canada and their subsequent import into the United States would be consistent with the Convention on International Trade in Endangered Species ("CITES") and would not be likely to contribute to illegal trade of bear parts (FWS 2001). Sport hunting is currently allowed only in the Northwest Territories and Nunavut (FWS 2001).

Polar bear trophies may currently be imported from the following Canadian populations (assuming all other applicable requirements have been met): Southern Beaufort Sea, Northern Beaufort Sea, Viscount Melville Sound (subject to Canada lifting the moratorium on harvest from this population), Western Hudson Bay, M'Clintock Channel (only for polar bears lawfully taken on or before May 31, 2000), Lancaster Sound, and Norwegian Bay (50 C.F.R. 18.30(h)(2)(i)(1)). As discussed below, on January 11, 2001, M'Clintock Channel was removed from the list of approved populations due to an ongoing overharvest, and consequently only bears lawfully hunted prior to May 31, 2000 may be imported (FWS 2001). Since the import of polar bear trophies was authorized in 1997, 597 import permits have been issued (Marine Mammal Commission 2004; Table 14).

**Table 14: Polar Bear Trophies Imported From Canada, 1994-2003**
Source: Marine Mammal Commission (2004:129).

| **Year** | **Number of Polar Bear Trophies Imported** |
|---|---|
| 1997 | 132 |
| 1998 | 60 |
| 1999 | 142 |
| 2000 | 76 |
| 2001 | 71 |
| 2002 | 48 |
| 2003 | 68 |

Regulation of hunting in Canada is complex. Regulations are summarized in Table 15 (next page) and discussed further below. Canada's Co-Management system also requires that management changes, including harvest quota adjustments, not rely solely on scientific data but also take into account traditional knowledge (FWS 2001).

**Table 15: Summary of Regulations Covering Polar Bear Management in Canada as of 31 December 2000**

Source: Adapted from Lunn et al. (2002b:42-43).

| CATEGORY | Man. | Nwfnd. | NW Terr. | Nunavut | Ont. | Qué. | Yukon |
|---|---|---|---|---|---|---|---|
| Hunting | Closed | Reviewed annually: hunting permitted Feb-Jun in portion of Labrador north of Cape Harrison | Season varies between polar bear management areas: longest 1 Oct – 31 May; shortest 1 Jan – 31 May | Season varies between polar bear management areas: longest 1 Aug – 31 May; shortest 1 Jan – 31 May | Closed | No sport hunting | 1 Oct – 31 May in GMZ1 only |
| Who can hunt | A person who possesses a Ministerial permit | Licenses distributed by Labrador Inuit Association | A person who possesses a tag. Tags are distributed by the HTCs | A person who possesses a tag. Tags are distributed by the HTOs | Permissible kill by Treaty Indians | Inuits and Indians | Inuit only are issued polar bear tags |
| Quota | 27 (19 on loan to Nunavut; 8 retained for the Polar Bear Alert Program) | 6 | By settlement: 2000-01 quota is 103 (97+6 administered on behalf of the Yukon | By settlement: 2000-01 quota is 395 | Permissible kill of 30 (by restricting sales over 30) | None | 6 (all of which are administered by the NWT) |
| Females and cubs protected by law | Yes | Females accompanied by cubs-of-the-year may not be taken | Yes, cubs defined by hide length | Yes | No | Yes | Yes |
| Bears in dens protected by law | Yes | Yes | Yes, also protects bears constructing dens | Yes, also includes bears constructing dens | No | Yes | Yes |
| Proof of origin of untanned bear | Documented proof | Documented proof (no seal on hide implemented to date) | Tag on hide and export permit | Tag on hide and export permit | Seal on hide, proof of origin required on imported hides | Seal on hide | Seal on hide, kill monitored by export permit |
| Export permit required and cost (out of province or territory of origin) | Required: no cost | Required: no cost | Required: No cost. There is a $750 Trophy Fee for non-residents and non-resident aliens | Required: No cost. There is a $750 Trophy Fee for non-residents and non-resident aliens | Required: no cost | Required: no cost | Required: no cost |
| Export permit out of Canada | Required by CITES for all polar bears or parts thereof exported out of Canada; obtained in Province or Territory exporting from | | | | | | |
| Scientific licenses | Discretion of Minister | Discretion of Minister | Discretion of Director, Wildlife and Fisheries | Discretion of Superintendent of Wildlife | Discretion of District Manager | Discretion of Minister | Discretion of Director, Field Services Branch |
| Selling of hide by hunter | Subject to conditions of Ministerial permit | Yes, must have been taken legally | Yes, must have tag attached | Yes, must have tag attached | Must be sealed by Ministry staff | Must be sealed; fee 5% of average value of last 2 years | Permit required from Conservation Officer |
| Basis of regulation | The Wildlife Act; reclassifies as protected species in 1991 | Wildlife Act, Chapter W-8 of The Revised Statutes of Newfoundland, 1990; classified as big game | Wildlife Act and Regulations; 1960 Order in Council (Endangered Species) | Wildlife Act and Regulations | Fish and Wildlife Conservation Act, 1997 (Statutes of Ontario, 1997 Chapter 41) | Wildlife Conservation and Management Act 1983; Order in Council 3234-1971; Bill 28-1978 (James Bay Agreement) | Wildlife Act 1981; Wildlife Regulations |

### 1. *Nunavut*

Nunavut split from the Northwest Territories[19] and obtained a separate polar bear quota for the first time in the 1998-1999 management year (Lunn et al. 2002b). The 2000-2001 polar bear quota was 395 bears in Nunavut (Lunn et al. 2002b). In January, 2005, the polar bear harvest in Nunavut was increased to 518 bears (Table 11 (page 111); Government of Nunavut 2005).

Nunavut harvests from the Northern Beaufort, Viscount Melville Sound, M'Clintock Channel, Gulf of Boothia, Lancaster Sound, Norwegian Bay, Kane Basin, Baffin Bay, Davis Strait, Western Hudson Bay, Southern Hudson Bay, and Foxe Basin populations. As described below, harvest levels were already likely unsustainable for several polar bear populations harvested by residents of Nunavut prior to the 2005 quota increase. The approximately 28% increase in hunting overall in Nunavut could lead to unsustainable harvest in additional populations, as discussed below.

Between 17 and 37 polar bears were harvested annually from the M'Clintock Channel population throughout the 1990s (Table 16). Canada initiated a new study of the M'Clintock Channel population in 1998 (FWS 2001). Both preliminary and updated results from this study indicated that the M'Clintock Channel population estimate of 700 bears was far too high and that the population was suffering from overharvest (FWS 2001). A new population estimate of between 238 and 399 bears, with a "best preliminary estimate" of 288, was calculated by the Government of Nunavut (FWS 2001). Based on this estimate, the Government of Nunavut recalculated the maximum sustainable harvest that would support the population at its current level with no population growth at 8 bears with a 1M:1F sex ratio (FWS 2001). The quota that had been set since 1993 was 32 to 34 bears, a rate of harvest that would reduce the population to zero in 10 years (FWS 2001). With no harvest, the population would increase at only 4 percent annually, and would likely take 25 years to double (FWS 2001).

**Table 16: Polar Bear Harvest in M'Clintock Channel, 1989/1990 through 1998/1999**
Source: Adapted from FWS (2001).

| Season | Bears Harvested |
|---|---|
| | |
| 1989-90 | 37 |
| 1990-91 | 32 |
| 1991-92 | 38 |
| 1992-93 | 20 |
| 1993-94 | 22 |
| 1994-95 | 17 |
| 1995-96 | 26 |
| 1996-97 | 28 |
| 1997-98 | 24 |
| 1998-99 | 22 |
| Total | 266 |

On January 11, 2001, the FWS removed M'Clintock Channel from the list of populations from which polar bear trophies taken legally in Canada may be imported into the United States via an

[19] The Northwest Territories was divided into two territories – the western portion of the previous Northwest Territories which retained the name, and the eastern portion which is now the territory of Nunavut (Lunn et al. 2002b).

emergency rulemaking, based on the unsustainability of the harvest (FWS 2001). On January 16, 2001, the Government of Nunavut reduced the quota for the M'Clintock Channel Population to 12 bears (2M:1F) for the 2000-2001 hunting season, and instituted a hunting moratorium for the 2001-2002 season (FWS 2001). Increasing the quota from zero to three bears in the M'Clintock Channel polar bear population is likely not compatible with recovery of this population.

The sustainable harvest for the Gulf of Boothia population set by the PBSG is 34 bears, based on a 900-bear population estimate with a certainty of estimate classified as "poor" (Lunn et al. 2002a). The Government of Nunavut increased the Gulf of Boothia quota from 41 to 74 bears in 2005. Overhunting is now likely impacting this population.

The Government of Nunavut also increased the quota for the Lancaster Sound population beyond the sustainable harvest set by the PBSG. The PBSG level is 77 bears (Lunn et al. 2002a), and the new quota set by Nunavut is 85 bears.

Overharvest also affects the Kane Basin population. Prior to 1997, this population was essentially not harvested in Canadian territory because of its distance from Grise Fiord, the nearest Canadian community, and because conditions for travel there are typically difficult (Stirling and Taylor 1999; Lunn et al. 2002a). However, this population has occasionally been harvested by hunters from Grise Fiord since 1997 and continues to be harvested on the Greenland side of Kane Basin (Stirling and Taylor 1999; Lunn et al. 2002a). In some years, Greenland hunters have also harvested polar bears in western Kane Basin and Smith Sound (Stirling and Taylor 1999; Lunn et al. 2002a). Few polar bears were encountered by researchers along the Greenland coast 1994 through 1997, possibly because of intense harvest pressure there (Stirling and Taylor 1999; Lunn et al. 2002a).

Based on preliminary data from ongoing research, the population estimate of 200 for Kane Basin would support a total cumulative harvest of approximately 9 bears per year (Stirling and Taylor 1999; Lunn et al. 2002a). The current best estimate of the Greenland kill is 10 per year, which is not sustainable (Lunn et al. 2002a). The actual number being taken by Greenland hunters is not known and must be validated (Lunn et al. 2002a). The Canadian quota for this population is 5 and if Canadian harvest continues from this area, overharvest and population depletion could occur (Stirling and Taylor 1999; Lunn et al. 2002a). Although the habitat appears suitable for polar bears on both the Greenland and Canadian sides of Kane Basin, the densities of polar bears on the Greenland (harvested) side were much lower than on the Canadian (unharvested) side; suggesting that this population may have been larger in past years, and could be managed for increase (Stirling and Taylor 1999; Lunn et al. 2002a). New information and methods developed by Canadian researchers also indicate that the Kane Basin population has been overharvested (Stirling and Taylor 1999).

Overharvest may also be occurring in the Baffin Bay population. Greenland does not limit the number of polar bears harvested, and preliminary population estimates and the most recent harvest information indicate that the population may be over-harvested (Lunn et al. 2002a; Stirling and Taylor 1999). Better information on population numbers and validation of the Greenland harvest data are required to clarify the status of this population (Stirling and Taylor 1999; Lunn et al. 2002a). Despite this concern, the Government of Nunavut increased the quota on this shared population from 64 to 105 bears in 2005 (Government of Nunavut 2005; Table 11 (page 111)). The sustainable harvest set by the PBSG is 93 bears from the Baffin Bay population (Lunn et al. 2002a). The Nunavut quota alone now exceeds this limit, and Greenland harvests from this population as well.

The Government of Nunavut also increased the quota for the Western Hudson Bay population from 47 to 56 bears (Government of Nunavut; Table 11 (page 111)), which alone exceeds the sustainable harvest for the Western Hudson Bay population, before the Manitoba defense of life and property take is included. Because the impact of global warming on parameters such as adult body condition and reproductive rates has already been documented in Western Hudson Bay, increasing the harvest quota beyond the sustainable harvest in this population is particularly troubling.

### *2. Northwest Territories*

Between the 1997-1998 and 1998-1999 management years, the Northwest Territories quota fell from 503 to 93 bears due to the creation of Nunavut as a new jurisdiction (Lunn et al. 2002b; Table 13 (page 115)). The 2000-1 quota was 97 bears in the Northwest Territories (Lunn et al. 2002b). The Northwest Territories now harvest from three populations, the Northern Beaufort Sea, Southern Beaufort Sea, and Viscount Melville Sound (Lunn et al. 2002b). The Southern Beaufort Sea population is shared with Alaska and the Northern Beaufort Sea and Viscount Melville Sound populations are shared with Nunavut (Lunn et al. 2002b). Management agreements for Northwest Territories polar bear populations were under revision at time of the last PBSG meeting (Lunn et al. 2002b). The management agreements in effect at that time required that all "problem bear" kills be included in the hunting quota (Lunn et al. 2002b). Approximately 44 "problem bears" were killed between 1972 and 1999 in the Northwest Territories (Lunn et al. 2002b).

### *3. Manitoba*

Manitoba shares management of the Western Hudson Bay population with the territory of Nunavut. The sustainable harvest for the Western Hudson Bay population is reported as 52 bears (Lunn et al. 2002a). A quota of 55 bears has in the past been divided between Manitoba (27 bears) and Nunavut (28 bears) (Lunn et al. 2002b). As part of its compliance with the International Agreement on the Conservation of Polar Bears, Manitoba has designated the polar bear as a protected species, and the Manitoba quota is used only for polar bear control in and around the Churchill town site (Lunn et al. 2002b). Based on the average number of bears killed by Manitoba Conservation staff, sent to zoos, and accidental deaths while immobilized, Manitoba itself uses eight of its 27-bear quota, and "loans" the rest to Nunavut for hunting (Lunn et al. 2002b). As discussed above, the Government of Nunavut increased its harvest quota to 56 bears in 2005, which itself is exceeds the sustainable kill for the Western Hudson Bay population. If Manitoba takes an average of 8 "problem bears" in addition to the 56 bears taken by Nunavut, this will significantly exceed the sustainable harvest set by the PBSG.

### *4. Newfoundland and Labrador*

The hunting quota for Newfoundland and Labrador has been 6 bears since the 1998-1999 management year (Lunn et al. 2002b). In the 1999-2000 management year, Newfoundland exceeded this quota by one bear (Lunn et al. 2002b). While hunting regulation is reviewed annually, there have been no changes in polar bear management in Newfoundland since at least 1993 (Lunn et al. 1998; Lunn et al. 2002b).

### *5. Ontario*

Ontario's quota of 30 polar bears has remained unchanged, and unfilled, in recent years (Lunn et al. 2002b). On January 1, 1999, the new Fish and Wildlife Conservation Act ("FWCA") of Ontario replaced the previous law and provided several management changes in Ontario. Under the new law there is no open season for polar bears, though some native trappers may obtain a trapping license and harvest a limited number of bears (Lunn et al. 2002b). A permit is also needed to possess or sell polar bears pelts, and all transactions must be recorded (Lunn et al. 2002b). Data collection on polar bear harvest may improve under the new regulatory scheme (Lunn et al. 2002b).

In January 1999, the Committee on the Status of Species at Risk in Ontario (COSSARO) listed the polar bear as "Vulnerable" in the province (Lunn et al. 2002b).

#### *6. Québec*

Québec's harvest quota is 62 polar bears (Lunn et al. 2002b). Polar bears may only be killed in Québec by native people pursuant to their traditional rights as recognized by the governments of Québec and Canada (Lunn et al. 2002b). The law in Québec provides that harvest levels should be guaranteed to native hunters as long as the principles of conservation are respected (Lunn et al. 2002b). After negotiation on an agreement on a polar bear hunting season, the protection of females with cubs, and a prohibition on the hunting of bears in their summer refuge, additional hunting restrictions may not be imposed (Lunn et al. 2002b).

### C. Greenland

Greenland shares three populations, Kane Basin, Baffin Bay, and Davis Strait, with Canada, and both countries exploit these populations at relatively high levels (Born 2002). There are no hunting quotas in Greenland, but in 1994 management and protection guidelines were introduced (Jessen 2002). These guidelines include the following: (1) trophy hunting is prohibited; (2) only Greenland residents who hunt as a full-time occupation may hunt polar bears; (3) polar bears are fully protected in July and August, except for single, adult male bears which may be taken all year long; (4) cubs younger than 12 months and their mothers are fully protected in the municipalities of Qaanaaq/Thule and Upernavik of NW Greenland and Ittoqqortormiit and Tasiilaq/Ammassalik of E. Greenland – in the remainder of Greenland, cubs younger than 24 months and their mothers are completely protected; (5) all catches including struck-and-lost polar bears must be reported to the Greenland management authorities; (6) aircraft, helicopters, motorized vehicles, and boats larger than 40 GRT are not allowed in the hunt or for transportation to and from the hunting grounds; (7) poison, traps, foot snares or self-shooting guns are not allowed; and (8) rim-fire rifles, shotguns or semi-or fully automatic weapons are not allowed (Jessen 2002). In November 2000, the Greenland Home Rule government decided, in principle, to work towards the introduction of quotas and other catch-regulating mechanisms in the Greenland hunt (Jessen 2002).

Data on the polar bear hunt in Greenland has only been collected since the beginning of 1993, via a voluntary system called the "Piniarneq" (Jessen 2002). All hunters require an annual hunting license that covers the hunting year from September through September, and at the time a hunter pays a small fee for his next-year license he must report his previous year's catch (Jessen 2002). Catch summaries are reported by municipality, and therefore the Piniarneq system does not track exact kill localities (Jessen 2002).

Data in the Piniarneq are subject to a high degree of error and to date have not been validated, and therefore data from the Piniarneq should be interpreted cautiously (Jessen 2002). One possible source of error is under-reporting due to hunters simply not turning in the required summaries (Jessen

2002). One reason for this could be that the hunters themselves are not used to paperwork and are not convinced that there is any benefit to keeping records (Jessen 2002). In one study of the Greenland catch of ringed seals, 4100 licenses were issued in 1993 and only 3403 reports were returned, indicating a possible 20% under-reporting of the catch (Jessen 2002). Over-reporting is also possible, because sometimes more than one hunter on a hunt will report a polar bear kill, even though only one bear was shot (Jessen 2002).

Generally, the polar bear kill numbers reported in the Piniarneq are higher than the previous system of reporting (Jessen 2002). This may be caused by one or more or a combination of the following factors: (1) the previous information was incomplete and estimates of non-reported catch was too low; (2) the Piniarneq over-estimates the catch due to over-reporting; (3) there is a real increase in the polar bear kill (Jessen 2002).

Polar bear catch data from Jessen (2002) are shown in Table 17, and Greenland municipality boundaries in Figure 23 (next page). During the period from 1993-1998, the reported Greenland polar bear kill averaged 145 bears per year (sd = 27.3, range: 121-198 bears per year, n = 6) (Jessen 2002). It appears that the catch of bears has increased during this period but as discussed above it is not clear if this is due to an actual increase in the catch or to improved data collection (Jessen 2002).

**Table 17: The Greenland Catch of Polar Bears (1993-1999) as Reported in the "Piniarneq"**
Source: Adapted from Jessen et al. (2002:69).

| Region | Municipality | 93 | 94 | 95 | 96 | 97 | 98 | 99 | Comments |
|---|---|---|---|---|---|---|---|---|---|
| NW and Central | Qaanaaq (Avanersuaq/Thule area) | 24 | 33 | 23 | 30 | 41 | 22 | 17 | Likely taken from the Baffin Bay management unit, but 10 may be taken from Kane Basin Management Unit |
| West Greenland | Upernavik | 43 | 25 | 27 | 40 | 38 | 48 | 47 | See above |
| | Pituffik | 0 | 0 | 0 | 0 | 0 | 0 | 0 | See above |
| | Uummannaq | 3 | 0 | 4 | 5 | 2 | 9 | 9 | See above |
| | Qeqertarsuaq/Disko | 6 | 1 | 1 | 0 | 0 | 5 | 2 | See above |
| | Ilulissat | 1 | 1 | 2 | 0 | 0 | 1 | 5 | See above |
| | Aasiaat | 4 | 3 | 1 | 0 | 3 | 3 | 8 | See above |
| | Qasigiannguit | 0 | 0 | 2 | 0 | 2 | 5 | 3 | See above |
| | Kangaatsiaq | 1 | 6 | 10 | 1 | 2 | 0 | 6 | Some may have been taken from Davis Strait management unit |
| | Kangerlussuaq/Sdr.Strom | 0 | 0 | 0 | 0 | 0 | 1 | 0 | See above |
| | Sisimiut | 0 | 1 | 4 | 1 | 1 | 12 | 4 | See above |
| | Maniitoq | 4 | 0 | 5 | 1 | 4 | 22 | 0 | Likely taken from Davis Strait management unit |
| | Nuuk | 0 | 0 | 1 | 4 | 0 | 0 | 2 | See above |
| SW Greenland | Ivittuut | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Likely taken from the East Greenland population |
| | Paamiut | 1 | 2 | 1 | 1 | 5 | 1 | 0 | See above |
| | Narsaq | 1 | 0 | 0 | 0 | 2 | 0 | 0 | See above |
| | Qaqortoq | 0 | 0 | 2 | 0 | 0 | 4 | 1 | See above |
| | Nanortalik | 1 | 0 | 6 | 3 | 6 | 9 | 11 | See above |
| East Greenland | Ammassalik | 15 | 14 | 22 | 23 | 9 | 13 | 14 | |
| | Illoqqortoormiut/Scoresbysund | 28 | 35 | 26 | 26 | 34 | 43 | 52 | |
| **Greenland Total** | | **132** | **121** | **137** | **135** | **149** | **198** | **181** | |

*1999 catch figures are provisional as they only include data for the period January-September
Source: Department of Fisheries, Hunting, Commerce, and Agriculture (Nuuk: in litt. January 2001).

**Figure 23: Greenland Municipality Boundaries**
Source: Jessen (2002:70).


Based on the limited available information, managers assign the catch taken in West Greenland in the municipalities from Qaanaaq south to Nuuk to the three populations shared with Canada (Jessen 2002). Bears taken from Qaanaaq and Sisimiut are assumed to be from the Kane Basin and Baffin Bay populations, and those taken from Maniitsoq and Nuuk are assumed to be from the Davis Strait population (Jessen 2002). As discussed above these three populations are all now subject to overharvest from the combined hunting in Canada and Greenland.

In the period 1993-1998 the catch reported for the Qaanaaq-Sisimiut region averaged 83 bears per year (sd = 13.1, range: 70-106 bears) (Jessen 2002). The estimate of the Greenland catch of polar bears between 1993-1998 from the Kane Basin population is 10, and the estimate from Baffin Bay population is 73 (Jessen 2002). The Greenland kill from the Davis Strait population is estimated to be as high as 13.5 bears per year (sd= 11.9; range: 5-35 bears) during 1993-1998, though Jessen (2002) notes that this estimate appears to be high.

The polar bear kill from Southwestern Greenland from 1993-1998 is estimated at 7.5 bears per year (sd =5.2; range: 3-14 bears) (Jessen 2002).

The polar bear kill from East Greenland increased significantly between 1993-1998 and is estimated to be 56 bears per year (range: 56-70 bears) (Jessen 2002). The sustainable harvest from East Greenland is unknown (Lunn et al. 2002a), leaving this population at considerable risk of overharvest.

### D. Norway

The Svalbard Archipelago is under Norwegian sovereignty pursuant to the Svalbard Treaty of 1920 (Derocher et al. 2002). Polar bear hunting in Svalbard has been banned since 1973, however, the Governor of Svalbard or the Head of Station in Jan Mayen can kill or give permission to kill any polar bears which remain close to permanent or temporary human settlements and thus are perceived to present a risk of injury to people or other “substantial” damage (Derocher et al. 2002). All such killings are either approved by or investigated by the Governor (Derocher et al. 2002). There are 250 private cabins on Svalbard, and there were nine bears shot between 1997-2000; no charges were brought in any of these instances (Derocher et al. 2002). Norway also continues to export polar bear skins and parts pursuant to CITES regulation (Derocher et al. 2002). Between 1996-2000, Norway exported 16 hides and 636 polar bear “pieces” (Derocher et al. 2002).

### E. Russia

Polar bear hunting in the Russian Arctic has been banned since 1956 (Belikov et al. 2002). However, there is an ongoing illegal kill in Chukotka, discussed under “Bering/Chukchi Sea Population,” above. The recent U.S.-Russia polar bear Agreement, which would legalize hunting by native peoples subject to sustainable harvest limits and other restrictions, is also discussed in that section. Russia has also considered opening harvest within the Barents Sea-Svalbard population, which is shared with Norway (Derocher et al. 2002).

# Appendix D: The Impacts of Contaminants on Polar Bears

Many Arctic species, including the polar bear, carry extremely high levels of contaminants such as persistent organic pollutants ("POPs"). The majority of the Arctic POP load is transported to the Arctic from distant sources. These pollutants have caused and will continue to cause adverse impacts on the immune systems, thyroid systems, and reproductive systems of polar bears. Other Arctic pollutants, such as heavy metals and radioactivity, may also threaten polar bears. Below we summarize the best available science on the ways in which contaminants threaten polar bears.

## I. PATHWAYS OF ARCTIC CONTAMINATION

In many respects, the Arctic is one of the most pristine places left on the earth. Yet the Arctic also contains high loads of many toxic pollutants that are transported from different sources by a number of mechanisms.

Air, water, and ice carry contaminants great distances to, from, and within the Arctic (AMAP 2002). In the global climate system, the Arctic cools the air and water warmed in more temperate regions (AMAP 2002). Cooler air can hold less moisture, and thus the Arctic is dry (AMAP 2002). As the cooling air releases rain and snow, contaminants are deposited as well (AMAP 2002). These contaminants end up on the ground, in melt water in rivers, and in the top layer of the ocean, where biological productivity is highest (AMAP 2002). Sea ice can carry contaminants across the Arctic and deposit them in the biologically productive melting zone of the North Atlantic (AMAP 2002).

Ocean currents are a slow but important pathway for contaminants to and within the Arctic (AMAP 2002). For radionuclides in particular, ocean currents are major routes from coastal sites outside the Arctic to marine food webs in the Arctic.

Rivers carry contaminants and process them through sedimentation and resuspension of particles (AMAP 2002). Lakes, deltas, and estuaries serve as sinks for contaminants in sediment (AMAP 2002). Seventy percent of the fresh water entering the Arctic Ocean flows from Russian rivers which are known to carry contaminants (FWS 1995).

The transport and deposition of contaminants follow seasonal patterns (AMAP 2002). In winter, the Arctic is home to a stable zone of high pressure centered over the Arctic Ocean and reaching far to the south (AMAP 2002). This polar air mass becomes a trap for airborne contaminants, especially those generated in the industrial areas of Eurasia (AMAP 2002). In spring and summer, the energy from sunlight breaks up this system, causing greater mixing with air from lower latitudes (AMAP 2002).

Several biological and physical processes concentrate POPs at some locations and in some species, such as the polar bear, causing some extremely high levels in the Arctic (AMAP 2002). While most POP sources are outside the Arctic, there are also local sources such as abandoned military sites, areas of mineral exploration, coal mining, and heavy industry, and harbors which can cause locally significant impacts (AMAP 2002).

Many pollutants, especially many types of POPs, dissolve in fat, and thus become concentrated in Arctic animals (AMAP 2002). This process, called biomagnification, is particularly prominent in long, fat-dominated food webs, and is of special concern in an apex predator such as the polar bear

(AMAP 2002). Polar bears may receive PCB concentrations that are three billion times higher than concentrations in ocean water (FWS 1995). Another process, called bioaccumulation, operates when contaminants are difficult for animals to excrete and thus accumulate throughout the life of an animal (AMAP 2002). Where bioaccumulation is at work, older animals can have much higher levels of a pollutant than younger animals (AMAP 2002). In addition, scavengers can bring these pollutants back into the food web, keeping them circulating for long periods even without additional inputs (AMAP 2002). Both biomagnification and bioaccumulation lead to extraordinarily high concentrations of some contaminants in polar bear tissue.

## II. PERSISTENT ORGANIC POLLUTANTS

Persistent Organic Pollutants ("POPs") include a wide range of toxic substances produced by man, including PCBs, dioxins, and pesticides such as DDT (AMAP 2004). POPs are by definition highly persistent compounds, and the Arctic cold, as well as other factors such as lower OH radical concentrations at the poles, make them even slower to break down in the Arctic (AMAP 2002).

Chemicals which are industrial products or by-products include PCBs, HCBs, PCDD/Fs, PCNs, PAHs, and OCS (AMAP 2004).[20] There are 209 types of polychlorinated biphenyls (PCBs), most of which are highly persistent in the environment, and which are highly lipophilic (that is, they dissolve easily in fat) (AMAP 2004). Much of the research to date on the impacts of POPs on polar bears, discussed below, has focused on the impacts of PCBs.

Chemicals that are in the category of chlorinated pesticides include DDT, chlordane, heptachlor, dieldrin, aldrin, endrin and mirex (AMAP 2004). DDT and chlordane are of particular concern because of high levels of toxins derived from them found in top predators such as polar bears (AMAP 2004).

A summary of known impacts of selected POPs is provided in Table 18.

**Table 18: Overview of Toxic Properties of Selected Persistent Organic Pollutants**
Source: AMAP (2004:27).

▲= induction or increase, ▼= suppression or decrease

| | **Reproductive & developmental effects** | **Neurotoxic effects** | **Liver enzymes** | **Immune effects** | **Effects on thyroid & vitamin A** | **Cancer** | **Other** |
|---|---|---|---|---|---|---|---|
| Aldrin & Dieldrin | ▼reproduction | | Induces liver enzymes | Suppresses immune system | | Non-mutagenic. Increased liver tumors | |
| Chlordanes | ▼reproduction | | Induces liver enzymes | Suppresses immune system | | Non-mutagenic. Tumor promoter | |
| DDT & metabolites | Egg-shell thinning in bird eggs. ▼reproduction | | Induces liver enzymes | Suppresses immune system | ▼thyroid weight | | Over-stimulation of adrenal cortex |
| HCB | Fetotoxic. Deformities. ▼reproduction | | Induces liver enzymes | Suppresses immune system | ▼thyroid hormones. ▲thyroid stimulation hormone ▲thyroid weight | Non-mutagenic. Tumor promoter | ▲Porphyria (a blood disease causing skin and nerve damage) |

[20] For a complete description of POPs, see (AMAP 2004).

| | Reproductive & developmental effects | Neurotoxic effects | Liver enzymes | Immune effects | Effects on thyroid & vitamin A | Cancer | Other |
|---|---|---|---|---|---|---|---|
| Alpha-HCH | No information | | Induces liver enzymes | | | Non-mutagenic. Tumor promoter | |
| Beta-HCH | Estrogenic | | Induces liver enzymes | Suppresses immune system | ▲thyroid weight | Non-mutagenic. Tumor promoter | |
| Gamma-HCH (lindane) | Estrogenic and antiestrogenic. ▼reproduction | | Induces liver enzymes | | | Non-mutagenic. Tumor promoter | |
| Mirex | ▼reproduction | | Induces liver enzymes | Suppresses immune system | | Non-mutagenic. Induces tumors | |
| Toxaphenes | Fetotoxic. ▼reproduction | | Induces liver enzymes | Suppresses immune system | ▲thyroid weight. ▲thyroid stimulation hormone | Mutagenic. Potent carcinogen. Inhibits cell-to-cell communication | ▲bone brittleness in fish. Overstimulation of adrenal gland |
| Endosulfan | Fetotoxic. ▼reproduction | | Induces liver enzymes | Suppresses immune system | | Non-mutagenic | |
| Dioxin, furans, dioxin-like PCBs, and metabolites | Fetotoxic. Deformities. ▼reproduction | Permanent changes in learning, behavior, memory | Induces liver enzymes | Thymic atrophy. Supresses immune system | ▼thyroid hormones ▼Vitamin A | Non-mutagenic tumor promoters. Affects cell-to cell communication | ▲Por-phyria |
| Other PCBs | Fetotoxic. Deformities. ▼reproduction | Permanent changes in learning, behavior, memory. Decreased dopamine. | Induces liver enzymes | Supresses immune system | ▼thyroid hormones ▼Vitamin A | Non-mutagenic tumor promoters. Affects cell-to cell communication | ▲Por-phyria Overstimulation of adrenal cortex |
| Short-chained chlorinated naphthalenes | Fetotoxic. Deformities. ▼reproduction | ▼motor performance | Induces liver enzymes | No information | ▼thyroid hormones. ▲thyroid stimulation hormone | Non-mutagenic. ▲peroxisome proliferation. Inhibits cell-to-cell communication | |
| Poly-chlorinated naphthalenes | Embryotoxic ▼reproduction | | Induces liver enzymes | | | | |
| PBDE (flame retardant) | Estrogenic and antiestrogenic | Permanent changes in learning, behavior, memory | Induces liver enzymes | Supresses immune system | ▼thyroid hormones ▼Vitamin A | Non-mutagenic | |
| PFOS/PFOA | ▼reproduction | | | | | Non-mutagenic. Tumor promoter. ▲peroxisome proliferation. Inhibits cell-to-cell communication | |
| TBT and metabolites | Imposex in invertebrates | | Inhibits liver enzymes | Suppresses immune system | | May be carcinogenic | |

A number of POPs, including the notorious "dirty dozen" of PCBs, dioxins, furans, hexachlorobenzene, aldrin, chlordane, dieldrin, DDT, endrin, heptachlor, mirex, and toxaphene, are now regulated by several multi-national treaties, as discussed further under "Inadequacy of Existing Regulatory Mechanisms," below. Restrictions and/or prohibitions on manufacture and use of some of the most toxic substances have resulted in declining inputs into the environment and declining levels in the Arctic for some chemicals (AMAP 2004).

In some areas, such as Svalbard, PCB concentrations in polar bears declined through the 1990's (AMAP 2004; Lie et al. 2004). However, research indicates a leveling of observed decreases, and further decreases in PCB contamination may be slight (AMAP 2004; AMAP 2002). One reason for this is that peak concentrations of chemicals are lower, take longer to be reached, and take longer to decrease farther from the source – and the Arctic is far from the majority of PCB sources (AMAP 2004).[21]

However, production of many toxic substances has not yet been controlled. The U.S. and Japan are major sources of dioxins and furans (AMAP 2002). Hexachlorobenzene concentrations in the Arctic are unexplained, leading to the hypothesis that there are as yet unknown sources for this contaminant (AMAP 2002). Lindane and endosulfan are still in widespread use, and butyltin compounds are only partially regulated (AMAP 2002).

"New" chemicals that do or may have impacts similar to already regulated "legacy" chemicals are also cause for major concern. Polybrominated diphenyl ethers ("PBDEs") are part of a class of flame retardant chemicals used to treat fabrics and equipment (AMAP 2002). Many PBDEs are known to behave similarly to PCBs (AMAP 2002). PBDEs are found in TV-sets, computers, building material, foam cushioning, and textiles (AMAP 2002). PBDEs are not regulated and their use has increased in the last decade, with an annual worldwide production of over 200,000 tons (AMAP 2002). PBDE levels in the Arctic increased from 1982 to 1996, and actually doubled in one three year period (AMAP 2002). While PBDE levels in animals are still low compared to PCB levels, if left unchecked PBDE levels may be similar to PCB levels within a few decades (AMAP 2002). In general, most chemicals on the market today have not been adequately tested to determine their impacts on wildlife (Walker 2004).

## III. HEAVY METALS AND RADIOACTIVITY

Several heavy metals, including mercury, cadmium, and lead, as well as radioactivity, could pose a threat to Arctic ecosystems and wildlife, including the polar bear. Unlike POPs, heavy metals and radioactivity all have natural, in addition to man-made, sources (AMAP 2002). While we are not aware of any studies specifically linking high heavy metal concentrations or radioactivity to observed detrimental impacts in polar bears, a brief discussion is appropriate here since these substances have known harmful impacts to other species, including humans.

Mercury is toxic to plants and animals. In mammals, mercury causes nerve and brain damage, especially in fetuses and the very young, and can interfere with the production of sperm (AMAP 2002). In birds, high levels of mercury can cause erratic behavior, appetite suppression, and weight loss, and lower levels have been associated with reduced egg production and viability, as well as reduced embryo and chick survival (AMAP 2002). In fish, high mercury levels can cause damage to gills and sense of

[21] In addition, the transport of most POPs from point of origin to the Arctic is complex (AMAP 2002). POPs are picked up by the winds as gases in temperate and tropical regions (AMAP 2002). When temperatures drop, they condense onto atmospheric particles and other surfaces, reaching the ground via rain, snow, or direct deposition onto land and water (AMAP 2002). However, they can revolatilize when weather conditions change, re-entering the atmosphere for further transport (AMAP 2002). Higher temperatures, storms, snowmelt, or icemelt in spring can also encourage revolitilization of POPs (AMAP 2002). Soils contaminated with PCBs in the past via atmospheric deposition are now releasing them back into the air to begin the process anew (AMAP 2002). In general, transport of POPs from sources in North America and Eurasia is much higher in winter and early spring than in summer (AMAP 2002).

smell, interfere with absorption of nutrients, and can cause blindness (AMAP 2002). Plants with high concentrations of mercury have reduced growth (AMAP 2002).

Recently, a phenomenon termed "mercury depletion" has been discovered in the Arctic. Researchers first noticed in 1995 that mercury levels in the air dropped sharply around "polar sunrise," the time when the sun returns after the long Arctic winter (AMAP 2002). For a period each spring, spanning the time from polar sunrise through snowmelt, a series of chemical reactions occur which lead to greatly reduced mercury deposition in the Arctic (AMAP 2002). Because it has only recently been discovered, researchers do not know whether mercury depletion is an ongoing or a new phenomenon, perhaps increased or induced by global warming (AMAP 2002).

While not yet fully understood, mercury depletion and high mercury levels in the Arctic are cause for concern (AMAP 2002). In Greenland, for example, mercury levels in human and seal hair are three times higher than in the 15th century (AMAP 2002). While data for mercury levels in polar bears are not exhaustive, scientists have some information including the following: mercury levels in polar bear muscle are higher now in East Greenland than in the 1980's, though no change was observed in polar bear liver, kidney, or hair; mercury levels in polar bears are higher in the northwestern Canadian Arctic than in southern, northeastern, and eastern Greenland; and polar bears tend to have the highest mercury levels in the kidney as compared to other organs (AMAP 2002). In one study, polar bears from the Beaufort Sea had seven times the amount of mercury in their liver tissue and four times the amount of mercury in their muscle tissue than bears from the Chukchi Sea (FWS 1995). In some areas of North America and West Greenland, mercury levels are still increasing for marine birds and some mammals (AMAP 2002). Concern and additional research on the impacts of mercury on polar bears is clearly warranted.

Scientists have expressed concern about Arctic cadmium levels because high levels can cause kidney damage, disturbed calcium and vitamin D metabolism, and bone loss (AMAP 2002). Cadmium is removed very slowly from the body and can bioaccumulate (AMAP 2002). Cadmium levels vary widely throughout the Arctic, and more research is needed to understand its possible impacts on wildlife including the polar bear (AMAP 2002).

Lead is a heavy metal with well known toxic impacts. Lead contamination can lead to altered behavior from effects to brain and nerve tissue, as well as interference with many enzymes, kidney damage, anemia, intestinal dysfunction, and reproductive problems (AMAP 2002). Regulation of lead, particularly restrictions on leaded gasoline, is credited with widespread reductions in emissions and environmental levels of lead (AMAP 2002). Most countries within Arctic source regions for lead no longer allow the use of leaded gasoline, although its use is continuing, though declining, in Russia (AMAP 2002). Not all lead sources are well documented, and while lead levels are generally declining in the Arctic, there are some areas where they are not (AMAP 2002). While regulation has clearly reduced the threat posed by lead contamination, it is still a potential threat to the polar bear.

Exposure to radioactivity can damage living cells, cause cancer, and interfere with reproduction and population health. There are two Russian nuclear power plants located in the Arctic, as well as a handful of plants within 1000 km of the Arctic (AMAP 2002). There is, therefore, risk of a nuclear accident in the future exposure of polar bears to radioactivity. In the shallows near Novaya Zemlya, reactors containing nuclear fuel from vessels and submarines are submerged, causing a potential danger of radioactive contamination of marine ecosystems (Belikov et al. 2002).

## IV. ARCTIC CONTAMINANTS HARM POLAR BEARS

As fourth level, apex predators with extremely high fat content diets, polar bears bioaccumulate large amounts of POPs. A growing body of research focused on the risks posed by high POPs levels in polar bears, and particularly by PCBs, indicates that both the health of individual bears and the population status in some areas may be at risk from pollution. In 2001, the PBSG listed pollution as an environmental concern for the East Greenland, Barents Sea, Kara Sea, Laptev Sea, and Queen Elizabeth Islands populations (Lunn et al. 2002a). Since that time, information on the harmful impacts of pollution has continued to accumulate. As detailed below, research indicates that high POP levels in polar bears may impact their reproductive, immune, thyroid, and hormone systems, and may cause neurobehavioral impacts.

There has long been concern that high PCB concentrations in polar bears may cause a variety of detrimental impacts. One way to assess health impacts from PCBs is to compare PCB levels to contaminant loads that are known to affect the health of other species (AMAP 2002). (AMAP 2002). Assuming that polar bears are at least as sensitive to PCBs as species such as mink, rhesus monkey, and humans, the levels of PCBs in ringed and harp seals, and therefore the polar bear diet, exceed various health-based standards in areas such as neurobehavioral effects, offspring survival, and immunosuppresion (AMAP 2004). However, this comparative approach has inherent problems which are particularly acute with regard to the polar bear (AMAP 2002). This is because the polar bear is able to metabolize some PCBs but not others, polar bears have delayed implantation, which allow a contaminant to act on a fertilized egg for some time before implantation, and polar bears go through periods of fasting, during which POP levels in the blood and sensitive organs may reach much higher levels than in an animal with consistent fat levels (AMAP 2002). Accordingly, to better understand the impacts of PCBs on polar bears, researchers have carried out studies designed to detect direct signs of impacts to bears (AMAP 2002).

The results from one study of adult female bears with high PCB concentrations at Svalbard demonstrated impaired reproduction and cub survival (AMAP 2004; Skaare et al. 2002). The researchers suggested that high intake of PCBs by cubs at a critical period in their development could be leading to higher mortality (AMAP 2004; Skaare et al. 2002). While this study did not definitively establish a causal link between high PCB levels and reduced reproduction and cub survival (AMAP 2004; Skaare et al. 2002), a separate study documenting a lack of older females with cubs-of-the year from Svalbard compared to other populations supports this hypothesis (AMAP 2002; AMAP 2004).

In a study of bears from Western Hudson Bay, females who had lost their cubs had higher contaminant concentrations (including PCBs, DDTs, HCHs, chlorobenzenes, and chlordanes) than females whose cubs survived (AMAP 2002). In another study, the levels of the male hormone testosterone, which plays a vital role in sexual development, were low in bears with high PCB loads (AMAP 2002).

A 1999 study surveyed 52 experienced polar bear hunters regarding observations of aberrant bears including pathological changes and anomalies in internal organs (Lunn et al. 2002a; AMAP 2004). Thirteen anomalies were reported including additional nipples or claws, unilateral collapse of lung, abnormal and missing claws, partial melanism, missing limbs, and a malformed newborn, and an incidence of pseudohermaphrotidism. (Lunn et al. 2002a; AMAP 2004). A higher percentage of pseudohermaphrotidism is found in Svalbard than in other areas, but the direct link to PCB exposure is not clear.

An experimental study of bears from Hudson Bay and Svalbard found evidence of a significant impact of PCB loads on the immune system (AMAP 2002; Skaare et al. 2002; AMAP 2004; Lie et al. 2004). In this study, bears with higher PCB concentrations produced fewer antibodies in response to vaccinations than bears with lower PCB concentrations (AMAP 2004; Lie et al. 2004; Skaare et al. 2002). In addition, high PCB concentrations were correlated with decreases in IgG (the major immunoglobulin class in blood), indicating a possible suppression of antibody-mediated immunity (Skaare et al. 2002; Lie et al. 2004). A reasonable assumption flowing from this study is that the demonstrated impact of PCBs on the immune system may increase the susceptibility of polar bears to infection (Lie et al. 2004; AMAP 2004).

High PCB concentrations have also been shown to impact thyroid hormones and retinol, particularly in female polar bears (Skaare et al. 2002; AMAP 2004; Braathen et al. 2004). Thyroid hormones control fetal brain development and behavior, as well as growth, metabolism, and reproduction throughout the life of the animal (AMAP 2002). The researchers stated that the negative relationship found between PCBs and thyroid hormones raises concern about the possible effects of PCB exposure on the learning ability and behavior of polar bears with high PCB concentrations (Braathen et al. 2004). This study is also believed to be the first to document a possible sex difference in PCB-related effects on thyroid hormones in any mammal (Braathen et al. 2004).

Organochlorines, including pesticides and PCBs, are also suspected of decreasing cortisol levels in polar bears (Oskam et al. 2004). Researchers suggest that the negative relationship could be due to lifetime organochlorine exposure and therefore organochlorines could be considered a chronic stressor (Oskam et al. 2004).

A related issue is the increased risk posed by the various physiological processes impacting the level of PCBs present in the polar bear blood stream. High POP concentrations are sequestered in the large fat stores of polar bears, which increase greatly in circulation during long fasts where fat stores are utilized (Oskam et al. 2004). Cubs may attain particularly high levels of POPs due to transfer from the mother's milk (Lunn et al. 2002a; Oskam et al. 2004).

In sum, recent research indicates that POPs impact the endocrine system, immune system, and reproductive success of polar bears (Derocher et al. 2004). Recent research results indicate that population status and health of polar bears with very high PCB levels may be at risk (Skaare et al. 2002; AMAP 2004).

## V. INTERACTIONS BETWEEN CONTAMINANTS AND GLOBAL WARMING

Global warming will impact the transport, levels, and availability of contaminants in a number of ways termed "changing pathways" (AMAP 2002; AMAP 2003). While the precise interactions and results cannot yet be predicted with accuracy and confidence, and scientists warn to expect surprises, a number of important observations can shed light on likely mechanisms of change (AMAP 2002; AMAP 2003).

Data indicate that the overall pressure pattern in the Arctic has shifted from a low Arctic Oscillation Index to a High Arctic Oscillation Index (AMAP 2002; AMAP 2003). Scientists are not certain whether this change is due to global warming or is the result of natural climate cycles, but it is clear that certain changes flow from this shift (AMAP 2002). One result is increased and more efficient transport of contaminants to the Arctic via increased storminess and increased atmospheric connection between the Arctic and industrial regions of North America and Europe that are contaminant sources (AMAP 2002).

Re-mobilization of contaminants may also be a widespread problem (AMAP 2003). Historical disposal of wastes has occurred in the form of sewage lagoons, dump sites at now-abandoned defense radar stations, solid waste dumps in small Arctic communities, mine tailings, and oil drilling sumps (AMAP 2003). A large component of the containment strategy for these sites is the presence of permafrost, which is now melting in some areas and is projected to melt in many others (AMAP 2003). As permafrost melts, these substances can be washed directly into rivers or the ocean, and runoff can leach contaminants into groundwater (AMAP 2003).

Global warming may have other impacts as well, including increased mercury cycling from the melting of permafrost, with the Hudson Bay region particularly vulnerable due to high rates of permafrost melt and a large drainage basin (AMAP 2002). Mercury deposition could also increase (AMAP 2002). The melting of glaciers may turn them from DDT sinks into net sources of continuing DDT contamination (AMAP 2002).

Global warming is likely to cause changes in human behavior that will influence the level of contaminants in the Arctic as well. The disappearance of sea ice from many waters for much of the year will encourage shipping, tourism, oil exploration and other industrial activities which will bring associated contaminants (AMAP 2003). Increased shipping will increase the risk of introducing exotic species or diseases which will then affect native species (AMAP 2003). The expansion of commercial fisheries into the Arctic could alter the food web structure in the oceans (AMAP 2003). Global warming could also promote the spread of insect pests globally which would cause some countries to re-introduce or increase the use of pesticides (AMAP 2003). Global warming could create conditions suitable for domestic crops and thereby expand the region of agriculture or silviculture within the Arctic drainage basin (AMAP 2003). Finally, warming temperatures will likely contribute to human populations shifts northward, which will in turn to lead to increased local releases of contaminants closer to the Arctic (AMAP 2003).

Global warming may also cause biological responses that can increase the threat from contaminants, such as reorganizations within the food chain (AMAP 2003). Changes at lower trophic levels of the food web could have severe consequences for a top-level predator like the polar bear for contaminants that biomagnify (AMAP 2003). Biomagnification is often exponential so that even a small increase in contamination at bottom of the food chain can have a large impact on the top level (AMAP 2003).

A prominent example of large scale, bottom up change from warming temperatures was provided by the Surface Heat Budget of the Arctic Ocean ("SHEBA") experiment (AMAP 2003). When the sampling data were compared to Soviet data gathered 20 years earlier, a large decrease in large diatoms in the water column and microfauna within the ice was observed, promoting species more typical of freshwater ecosystems (AMAP 2003). The loss of relatively large diatoms could reduce the size of herbivores, potentially inserting an extra level at the bottom of the food web which would increase the number of trophic levels (AMAP 2003), thereby increasing biomagnification of contaminants in higher-level predators.

Polar bears have already begun to suffer from at least one interaction between global warming and contaminants. Polar bears, like many top predators in the Arctic, undergo a period of fasting forced by their inability to hunt seals when they are confined to land by the melting of the sea ice (AMAP 2003). Pregnant females that den on land may undergo fasts of as long as 8 months (Derocher et al. 2004). The burning of stored fat through metabolism during times of fasting results in release of archived fat-soluble contaminants, and, potentially, an increase of contaminant burden in the remaining fat reservoir. As discussed on pages 39-40 above, global warming and melting of sea ice is decreasing the feeding period and increasing the fasting period for bears in Western Hudson Bay (Derocher et al. 2004; AMAP 2003). One cumulative/synergistic impact from global warming is that longer periods of fasting due to change in ice or change in prey populations could lead to higher doses of POPs sequestered in fat, at a time when the animal can least afford it (AMAP 2003).

Polar bear populations also utilize a range of prey that can explain regional variation in contaminant burdens (AMAP 2003). For example, Chukchi and Bering Sea bears feed more heavily on Pacific walrus which are less contaminated than ringed seals because they feed at a lower trophic level, whereas bears from Svalbard feed on more heavily contaminated seals (AMAP 2003). Similarly, Olsen et al. (2003) recently discovered that space use strategy (e.g. the size of a female polar bear's home range) is an important factor in high body burdens of PCBs. Olsen et al. (2003) suggest that this is because polar bears with larger home ranges have higher energetic costs from feeding than bears with smaller home ranges, and therefore must consume more prey (and correspondingly more PCBs found in prey) in order to meet their energetic requirements. The authors suggest that space use strategy may be the most important determinant of variation in PCB concentration in the Barents Sea area, and may be an important factor in other areas as well (Olsen et al. 2003). Clearly, climate variables expressed through prey availability and biological condition can have large influence on polar bear exposure to contaminants (AMAP 2003).

# Appendix E: Regulatory Mechanisms are Inadequate to Address Other Threats to Polar Bears

## I. International Agreement on the Conservation of Polar Bears

Determined to halt the decline of the world's polar bear populations**,** Canada, Denmark, Norway, Russia, and the United States signed the Agreement on the Conservation of Polar Bears ("Polar Bear Agreement") in 1973. The Agreement requires signatories to protect the ecosystems and habitat used by polar bears and advance polar bear protection efforts through coordinated national measures. The Agreement is politically significant as the first time these five circumpolar nations reached unanimous agreement on a framework to resolve a circumpolar issue (Stirling 1998). It is also significant as an example of a scientifically sound management scheme incorporating both data collection and adaptive management (Stirling 1998).

In 1976, the US Senate unanimously granted its advice and consent to the Polar Bear Agreement.[22] All five parties ratified the Agreement by 1978. The Agreement was initially in force for five years, but became permanent upon agreement by the parties in 1981. Article II of the Agreement requires each country to "take appropriate action to protect the ecosystem of which polar bears are a part, with special attention to habitat components such as denning and feeding sites and migration patterns," and to "manage polar bear populations in accordance with sound conservation practices based on the best available scientific data." Article VI requires each country to "enact and enforce such legislation and other measures as may be necessary" to implement the Agreement. Although each party must enact implementing legislation where necessary, the Agreement does not preclude a party from establishing more stringent controls than those required under the Agreement, and creates an affirmative duty for each country to take appropriate action to protect the polar bear ecosystem.

As discussed above, the Polar Bear Agreement is widely regarded as an early example of a great wildlife management success story. Following the Polar Bear Agreement, overhunting was curtailed, polar bear populations recovered, and critical scientific and management bodies such as the PBSG were established. However, the Agreement is not perfect and has weaknesses including the fact that its terms have not been enforceable in any country and that there is no infrastructure to oversee compliance. In 1982, Parties to the Polar Agreement met to discuss the habitat and ecosystem protection goal of Article II (Baur 1996). The Parties agreed that more had to be done to protect specified habitat areas. Specifically, they determined that national efforts should be directed toward identification of important denning and feeding areas. The Parties also agreed that these areas needed more protection from disturbance and destruction (Baur 1996).

As discussed below, the United States has never fully complied with the Agreement, with the important consequence that oil and gas development continues to sprawl across the Alaskan Arctic and pose an ever greater threat to polar bears. The Agreement has also not prevented illegal hunting in some areas that continues to pose a threat to certain populations. Finally, while the United States and other signatory countries should be forced to address the greatest threat to the polar bear, global warming, under the terms of the Agreement, the United States has not done so, and the Agreement also provides no mechanism for addressing emissions of non-signatory countries. For all these reasons, the Agreement is not and has not been sufficient to remove the need for listing under the ESA.

[22] 122 Cong. Rec., 29,699, 29,702 (Sept. 10, 1976); 122 Cong. Rec. 30,432 (Sept. 15, 1976).

Both the Executive branch and the United States Congress have viewed the Marine Mammal Protection Act ("MMPA," 16 U.S.C. § 1361 et seq.) as the implementing mechanism to comply with binding obligations of the Agreement. However, with the exception of governing imports of polar bear parts and trophies from the 19 non-US populations of the polar bear, the MMPA is capable of addressing threats only to the US-Canada and US-Russia populations. While the MMPA provides some protection to polar bears within the United States, it is incapable of addressing several of the major threats even to those two populations, including global warming and the impacts of pollutants. Finally, as described further below, the MMPA has failed even to protect United States populations of polar bears from the threats posed by the oil and gas industry, threats which the MMPA was designed to ameliorate. The FWS has repeatedly authorized the incidental take of polar bears as a consequence of oil and gas activity pursuant to the MMPA, but has failed to take the necessary steps to protect the denning and feeding areas essential for polar bear survival.

## II. THE US MARINE MAMMAL PROTECTION ACT

In response to growing concern regarding the welfare of marine mammals, the United States Congress enacted the MMPA in 1972 to prevent the extinction or depletion of marine mammal stocks as a result of man's activities. 16 U.S.C. § 1361(1). Understanding that marine mammals are in danger of extinction as a result of human activities, the goal of the MMPA is to protect and conserve marine mammals so that they are a significant functioning element of the ecosystem of which they are a part. 16 U.S.C. § 1361. The MMPA generally imposes a moratorium on the taking of marine mammals, including the polar bear, subject to certain statutory exceptions.[23] 16 U.S.C. §1371. Taking is defined to include the "harassment" of marine mammals. 16 U.S.C. §1362(13). "Harassment" includes any act of pursuit, torment, or annoyance which "has the potential to injure a marine mammal or marine mammal stock in the wild" (Level A harassment), or "has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering" (Level B harassment). 16 U.S.C. §1362(18).

The MMPA also places strong emphasis on habitat and ecosystem protection. The habitat and ecosystem goals set forth in the MMPA include: (1) management of marine mammals to ensure they do not cease to be a significant element of the ecosystem to which they are a part; (2) protection of essential habitats, including rookeries, mating grounds, and areas of similar significance "from the adverse effects of man's action;" (3) recognition that marine mammals "affect the balance of marine ecosystems in a manner that is important to other animals and animal products" and that marine mammals and their habitats should therefore be protected and conserved; and (4) directing that the primary objective of marine mammal management is to maintain "the health and stability of the marine ecosystem." *Id.* § 1361(2)-(6). Congressional intent to protect marine mammal habitat is also reflected in the definition of terms set out in section of the MMPA. The terms "conservation" and "management" of marine mammals are specifically defined to include habitat acquisition and improvement. 16 U.S.C. § 1362(2).

The Secretaries of Commerce and the Interior have primary responsibility for implementing the MMPA. The Department of Commerce, through the National Oceanic and Atmospheric Administration ("NOAA"), has authority with respect to whales, porpoises, seals, and sea lions. The remaining marine

[23] Because neither of the two United States populations of the polar bear are currently designated as "depleted" (Angliss and Lodge 2004), Native subsistence hunting is allowed without limitation by the MMPA. However, as noted below, US-Canada and US-Russia treaties do regulate such hunting.

mammals, including polar bears, walruses, and sea otters, are managed by the Department of the Interior through the FWS. Both agencies are responsible for the promulgation of regulations, the issuance of permits, the conduct of scientific research, and enforcement. Section 112 of the MMPA confers general rulemaking authority on the Secretary of the Interior to "prescribe such regulations as are necessary and appropriate to carry out the purposes of [the MMPA]." 16 U.S.C. §1382(a).

US citizens who engage in a specified activity other than commercial fishing within a specified geographical region may petition the Secretary of the Interior[24] to authorize the incidental, but not intentional, taking of small numbers of marine mammals within that region for a period of not more than five consecutive years. 16 U.S.C. § 1371(a)(5)(A). The Secretary "shall allow" the incidental taking if the Secretary finds that "the total of such taking during each five-year (or less) period concerned will have a negligible impact on such species or stock and will not have an unmitigable adverse impact on the availability of such species or stock for taking for subsistence uses…" Id. If the Secretary allows the incidental taking, the Secretary must also prescribe regulations that specify (1) permissible methods of taking and (2) means of affecting the least practicable adverse impact on the species, their habitat, and their availability for subsistence uses, and (3) requirements for monitoring and reporting. The regulations promulgated by the FWS do not authorize the oil and gas activities themselves, but authorize issuance of Letters of Authorization ("LOAs") from the FWS to individual entities to conduct specific activities pursuant to the regulations. Id.

Since 1993, the oil and gas industry ("Industry") has sought incidental take authority for both polar bears and walrus from FWS for oil and gas development activities in Alaska, including the Beaufort Sea (FWS 2003). In 1993, the Secretary of the Interior issued incidental take authority for a period of 18 months and directed the FWS "to develop and begin implementing a strategy for the identification and protection of important polar bear habitats" during this time in order to comply with the US government's obligation under both the Polar Bear Agreement and the MMPA to protect the ecosystems of which polar bears are a part, with particular attention to denning and feeding sites, and migration patterns (FWS 1993, 1995, 2003). In its 1995 Habitat Conservation Strategy for Polar Bears in Alaska ("Polar Bear Strategy"), the FWS identified Important Habitat Areas ("IHAs") for polar bears, including recurring leads and polynyas, carcass feeding areas, and important terrestrial and near shore maternity denning areas.[25] The IHAs are depicted in Figure 14 (page 66). The FWS stated that "there is a high probability and reasonable likelihood of incidental take of polar bears" from oil and gas activities conducted within these IHAs (FWS 1995:64).

Unfortunately, the designation of these IHAs has provided little or no real protection to polar bears or their essential habitat, as oil and gas development has continued to proliferate throughout Alaska's Arctic. Even the Arctic Refuge is now threatened by oil and gas development, as opening the Refuge is one of the top priorities of the Bush Administration. The FWS issued 223 LOAs for oil and gas development between 1993 and 2003 (FWS 2003). The FWS issued an additional 20 LOAs in 2004 (FWS 2004a; 2004b). Oil and gas activities have not been prohibited within the IHAs. The LOAs may (but are not required to, and do not always) require measures such as avoidance of polar bear dens, intensified monitoring within one mile of a den, or avoidance of a den area until a specific date (FWS

[24] The Secretary of the Interior has delegated her duties to the FWS.

[25] As part of the Polar Bear Strategy, the FWS also included a Village Communication Plan, a Polar Bear Advisory Council, and statement on the importance of the Arctic Refuge to polar bear maternity denning (including the position that any Congressional action to open the Refuge to oil and gas development may necessitate a review of compliance with the Polar Bear Agreement), and a proposal to coordinate international cooperative conservation efforts (FWS 1995).

2003). While the ability to locate occupied dens has improved, there is no certainty that all dens within an area to be impacted by development activities will be located (FWS 2003).

There are numerous other reasons why this regulatory structure has been insufficient to protect polar bears, including the fact that the FWS incidental take regulations have never been sufficiently protective. One example of how and why this is so is the FWS response to the US Marine Mammal Commission's comments on the FWS's most recent rule authorizing incidental take of marine mammals associated with ongoing oil and gas development in Alaska and the Beaufort Sea. The Marine Mammal Commission commented as follows: (1) that the FWS establish a mechanism to evaluate and, if appropriate, authorize the incidental taking of marine mammals associated with, but occurring outside the geographic range of, the Beaufort Sea Multiple Lease Sale project area, such as shipping traffic in the Bering and Chukchi Seas; (2) that the FWS conduct a thorough analysis of possible impacts of oil and gas activities on polar bear hunting by the village of Nuiqsut prior to finalizing the regulations; (3) that the FWS modify its oil spill risk assessment to properly reflect the assumptions and uncertainties concerning the effects of oil spills on walrus and polar bears; (4) that the FWS conduct a complete review of possible cumulative impacts on polar bears and walrus; (5) that the FWS describe the mitigation measures in the final rule that will be required for industry to minimize impacts to polar bears; and (6) that the FWS develop and implement a monitoring program of sufficient resolution to detect changes in vital parameters in polar bear populations from oil and gas activities (Marine Mammal Commission 2004).

These important comments from the scientific body charged with oversight of the FWS's implementation of the MMPA's protections had almost no discernable impact on the FWS's action. In the final rule authorizing take of polar bears, the FWS responded to these concerns as follows: (1) that the FWS would not evaluate incidental take associated with but occurring outside the geographic definition of the Multiple Lease Sale project area as part of the current rulemaking but might do so in the future <u>if the oil industry requested that it do so</u>; (2) that it had adequately examined the impacts on Nuiqsut subsistence study and that there was no need for further study; (3) that there was currently no superior methodology for oil spill risk assessment but that it would continue to work towards improving existing methodologies; (4) that it agreed that a complete cumulative impacts assessment for the polar bear and walrus is needed, and would work towards collecting information to conduct one in the future; (5) that the required mitigation measures were included in the final rule; and (6) that it convened a small workshop in September 2003 to consider challenges relating to a monitoring program and that such a program is a "formidable task and a worthy goal" (Marine Mammal Commission 2004:118).

This example demonstrates that the FWS failed to incorporate the best available science (here, the comments from the Marine Mammal Commission), and therefore promulgated regulations insufficiently protective of polar bears. Moreover, there is no guarantee that even the FWS's minimal regulatory requirements will be applied to all oil and gas development in polar bear habitat within the US. The FWS has taken the position that the oil and gas industry is not required to seek incidental take authority for oil and gas activities, but has merely chosen to do so to avoid potential conflicts between their activities and the requirements of the MMPA (FWS 2003; 1993). There is no guarantee that the FWS will take enforcement action against entities that choose not to obtain take authority and then take polar bears. Moreover, there is no active enforcement mechanism that will ensure that entities that do obtain LOAs will comply with their requirements.

Although both the Polar Bear Agreement and the MMPA have been in force for close to 30 years, few affirmative steps have been taken to safeguard polar bear habitat, and the US has never fully complied with the Polar Bear Agreement. The US Congress itself, concerned that the United States was failing to meet its mandate under the Polar Bear Agreement, called for a review of the effectiveness and implementation of the Agreement as part of the 1994 MMPA Amendments, particularly with respect to Article II of the Polar Bear Agreement, by April 1, 1995. H.R. Rep. No. 103-439, at 35 (1994). Nearly a full decade after this statutory deadline, a final report is still pending. The draft Report, however, concludes that the United States is not in compliance with the Polar Bear Agreement because the requirement to protect essential polar bear habitat has never been met (FWS 1997).

The draft Report reaffirms this conclusion throughout stating that "[h]abitat protection measures as outlined in the Agreement are only partially fulfilled by the United States." (FWS 1997:18). The Report concludes that "[f]urther efforts must be made to fully address the habitat protection provisions in Article II of the Agreement, that is, to conserve denning and feeding sites and migration patterns, as well as the ecosystem of which polar bears are a part." (FWS 1997:20). In reaching this conclusion, the Report recognizes that both the incidental take regime and the 1993 Habitat Conservation Strategy are inadequate to comply with the affirmative mandate of the Agreement (FWS 1997:18)[26]:

> In the 1993 incidental take regulations, the Secretary of Interior also directed the Service to develop a *Habitat Conservation Strategy for Polar Bears in Alaska* (Strategy) as part of the rulemaking. Completed in August of 1995, the Strategy identifies important habitat areas used by polar bears for denning and feeding <u>but provides no new direct habitat protections, such as areas set aside specifically for polar bear protection</u> (FWS 1997:18) (emphasis supplied).

Finally, the Report concludes that opening the Arctic Refuge to oil and gas development would also likely violate the Agreement.

Aside from the unambiguous conclusions of the Secretary's long overdue report, it is clear that current polar bear habitat and ecosystem protections are inadequate to protect polar bears. Due to the shortcomings of existing regulatory mechanisms, the polar bear should be listed as a threatened species under the ESA.

## III. CANADA'S SPECIES AT RISK ACT

Canada's new Species at Risk Act ("SARA") was signed into law on December 12, 2002, and came fully into force on June 1, 2004 (Walton 2004). SARA provides an array of protections to wildlife species that are added to the official List of Wildlife Species at Risk, or "Schedule 1" species (SARA Registry 2005). A "wildlife species" is defined as a "species, subspecies, variety or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and (a) is native to Canada; or (b) has extended its range into Canada without human intervention and has been present in Canada for at least 50 years." SARA Art. 2.

SARA promotes species conservation through a number of mechanisms, including prohibitions on harming and killing listed species and destroying their residences and critical habitat, and the implementation of recovery strategies.[27] Significantly, however, due to Canadian constitutional issues,

[26] The Report also concludes that if lethal take were to occur pursuant to the incidental take regime, such take would violate the Agreement (FWS 1997).

[27] SARA prohibits the killing, harming, harassing, capturing, or taking an individual of a listed species that is extirpated, endangered, or threatened, and the possession, collection, purchase, sale, or trade of a listed species that is extirpated, endangered, or threatened. SARA also prohibits the damage or destruction of the residence of one or more individuals of a

the prohibitions apply to polar bears only on Federal lands, such as national parks, in Canada (Walton 2004). SARA contains a "safety net" for protection of species like the polar bear, in which the Federal Cabinet, on recommendation of the Minister of the Environment, may order that the prohibitions in SARA apply to non-federal lands in a Province or Territory (Walton 2004). However, if this provision were to be invoked, it would likely be challenged by entities seeking to limit SARA's reach, and therefore the ultimate disposition of the provision is unclear (Walton 2004).

SARA established the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), charged with evaluating scientific information relating to wildlife species at risk (SARA Art. 14; SARA Registry 2005). COSEWIC is required to "carry out its functions on the basis of the best available information, on the biological status of a species, including scientific knowledge, community knowledge and aboriginal traditional knowledge" (SARA Art. 15(2); SARA Registry 2004). COSEWIC fulfills a central role in the listing process, which consists of the following steps: (1) COSEWIC assesses the biological status of a species using the best available information, research, and Aboriginal traditional knowledge, and applies this to the listing criteria; (2) COSEWIC sends its assessment of the species to the Minister of the Environment, and posts the assessment in the public registry; (3) the Minister of the Environment must publish, within 90 days from receipt of the assessment, a report on how it intends to respond to the assessment and, to the extent possible, timelines for action; (4) within nine months of receiving the assessment, the Minister must decide whether or not to add the species to the List of Wildlife Species at Risk, or request more information from COSEWIC; and (5) if a decision is not made within nine months, the species is added to the List of Wildlife Species at Risk, according to the COSEWIC assessment. Thus, the final authority for listing decisions rests with politicians and the Federal Cabinet, rather than with the scientific agency, leading to concern that species may not receive the protection they deserve due to economic or political concerns (Walton 2004).

The polar bear is currently designated as a Schedule 3 species, as a "Species of Special Concern," awaiting re-assessment and public consultation for possible addition to Schedule 1. (Environment Canada 2005). As such, the polar bear currently does not receive protection under SARA, and therefore SARA is currently an inadequate regulatory mechanism for its protection.

Even if the polar bear were added to SARA's Schedule 1, however, SARA would still be inadequate to protect all polar bear populations for a number of reasons. First, SARA provides protection only to species in Canada, and only on Federal lands within Canada. Therefore, SARA does not protect polar bear populations outside of Canada, and provides only limited protections even to Canadian polar bear populations. In addition, with some limited exceptions[28] SARA does not provide for citizen enforcement like the Endangered Species Act. Over 30 years of experience with the

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listed endangered or threatened species or of a listed extirpated species if a recovery strategy has recommended its reintroduction (SARA Art. 32 and 33; SARA Registry 2005). SARA also provides for the preparation of a Recovery Strategy for Schedule 1 species, as well as an Action Plan to implement Recovery Strategies for extirpated, endangered, and threatened species, and Management Plan for species of special concern (SARA Registry 2005). SARA also provides for the protection of the habitat necessary for the survival and recovery of listed species, termed "critical habitat" (SARA Arts. 56-64; SARA Registry 2005).

[28] SARA does provide for public involvement in the listing process, and for Canadian Citizens to request investigations into alleged SARA violations (SARA Registry 2004). Additionally, while there is not explicit authority in SARA for a citizen enforcement action, citizen petitions for emergency enforcement action under Article 80 have been filed in Canada. However, the first such petition to protect the spotted owl on an emergency basis was denied by the Minister of the Environment (Walton 2004).

Endangered Species Act in the US has demonstrated that citizen enforcement via citizen suits is vital to the Act's success. See, e.g. Friends of the Earth v. Consolidated Rail Corp., 768 F.2d 57, 63 (2d Cir. 1987). Finally, SARA does not provide an effective mechanism for combating global warming, the primary threat to the polar bear.

It should also be noted that the criteria for listing under SARA, set forth in Table 19, are different than the criteria for listing under the Endangered Species Act. The listing criteria used by COSEWIC are based on the IUCN (2001) Red List assessment criteria. The polar bear qualifies, at a minimum, as "threatened" under SARA, but it is unclear when and if it will be officially listed (i.e., added to Schedule 1) in Canada.

**Table 19: Criteria for Listing Species as Threatened or Endangered under the Canadian Species at Risk Act**
Source: Adapted from SARA Registry 2005.

| | **ENDANGERED** | **THREATENED** |
|---|---|---|
| **A. DECLINING TOTAL POPULATION – Reduction in population size based on any of the following 4 options and specifying a-e as appropriate** | | |
| | ≥ 70 % | ≥ 50 % |
| | (1) population size reduction that is observed, estimated, inferred, or suspected in the past 10 years or 3 generations, whichever is longer, where the causes of the reduction are clearly reversible AND understood AND ceased, based on (and specifying) any combination of a-e below. | |
| | ≥ 50 % | ≥ 30 % |
| | (2) population size reduction that is observed, estimated, inferred, or suspected in the past 10 years or 3 generations, whichever is longer, where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any combination of a-e below. | |
| | (3) population size reduction that is projected or suspected to be met within in the next 10 years or 3 generations, whichever is longer (up to a maximum of 100 years), based on (and specifying) and combination of b-e below. | |
| | (4) population size reduction that is observed, estimated, inferred, projected or suspected over any 10 year or 3 generation period, whichever is longer (up to a maximum of 100 years), where the time period includes both the past and the future, AND where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any combination of a-e below. | |
| | **a)** direct observation<br>**b)** an index of abundance appropriate for the taxon<br>**c)** a decline in area of occupancy, extent of occurrence and/or quality of habitat<br>**d)** actual or potential levels of exploitation<br>**e)** the effects of introduced taxa, hybridization, pathogens, pollutants, competitors, or parasites | |
| **B. SMALL DISTRIBUTION, AND DECLINE OR FLUCTUATION** | | |
| 1. Extent of occurrence | $< 5{,}000\ km^2$ | $< 20{,}000\ km^2$ |
| OR | | |
| 2. Area of occupancy | $< 500\ km^2$ | $< 2{,}000\ km^2$ |
| **For either of the above, specify at least two of a-c:** | | |
| (a) either severely fragmented or known to exist at # locations | ≤ 5 | ≤ 10 |
| (b) continuing decline observed, inferred or projected in any of the following: | | |
| | i) extent of occurrence | |

| | ENDANGERED | THREATENED |
|---|---|---|
| | ii) area of occupancy<br>iii) area, extent and/or quality of habitat<br>iv) number of locations or populations<br>v) number of mature animals | |
| (c) extreme fluctuations in any of the following: | > 1 order of magnitude | > 1 order of magnitude |
| | i) extent of occurrence<br>ii) area of occupancy<br>iii) number of locations or populations<br>iv) number of mature animals | |
| **C. SMALL TOTAL POPULATION SIZE AND DECLINE** | | |
| Number of mature individuals | < 2,500 | < 10,000 |
| And 1 of the following 2: | | |
| (1) an estimate of continuing decline at a rate of at least: | 20% in 5 years or 2 generations (up to a maximum of 100 years in the future) | 10% in 10 years or 3 generations (up to a maximum of 100 years in the future) |
| (2) continuing decline, observed, projected or inferred, in numbers of mature individuals and at least one of the following (a-b): | | |
| (a) fragmentation – population structure in the form of one of the following: | (i) no population estimated to contain >250 mature individuals | (i) no population estimated to contain >1,000 mature individuals |
| | (ii) at least 95% of mature individuals in one population | (ii) all mature individuals are in one population |
| (b) extreme fluctuations in the number of mature individuals | | |
| **D. VERY SMALL POPULATION OR RESTRICTED DISTRIBUTION** | | |
| (1) Number of mature individuals | < 250 | < 1,000 |
| (2) Applies only to threatened: Population with a very restricted area of occupancy or number of locations such that is prone to the effects of human activities or stochastic events within a very short time period in an uncertain future, and thus is capable of becoming highly endangered or even extinct in a very short time period. | | |
| | (not applicable) | Area of occupancy typically < 20 km² or number of locations ≤ 5 |
| **E. QUANTITATIVE ANALYSIS** | | |
| Indicating the probability of extinction in the wild to be at least: | 20 % in 20 years or 5 generations, whichever is longer (up to a maximum of 100 years) | 10 % in 100 years |

## IV. THE MONTREAL PROTOCOL AND NATIONAL MEASURES TO REGULATE POLLUTANTS

Some greenhouse gases such as CFCs are regulated under the Montreal Protocol because they also cause depletion of the stratospheric ozone layer (Albritton et al. 2001). The combined tropospheric abundance of ozone-depleting gases peaked in 1994 and is now declining slowly (Albritton et al. 2001). However, some compounds which were both previously used and promoted as substitutes for now-regulated CFCs are themselves greenhouse gases, and concentrations of these gases, such as hydrochloroflurocarbons ("HCFCs") and hydroflurocarbons ("HFCs") are now increasing (Albritton et al. 2001). However, the current contribution of these gases to global warming is relatively small, and their future use is regulated under the Montreal Protocol (Albritton et al. 2001).

Since the 1970s, the manufacture, use, and emissions of many pollutants that collect in the Arctic have been restricted by various regulatory mechanisms of individual countries (AMAP 2002). At the international level, several treaties now regulate some POPs as well, including the notorious "dirty dozen" which includes PCBs, dioxins, furans, hexachlorobenzene, aldrin, chlordane, dieldrin, DDT, endrin, heptachlor, mirex, and toxaphene. The Convention on Long-range Transboundary Air Pollution covers Europe, all states of the former Soviet Union, and North America. The Stockholm Convention on Persistent Organic Pollutants also identifies some POPs to be banned or restricted. All countries which participate in the Arctic Monitoring and Assessment Programme have signed both conventions, but only a handful of countries have ratified each (AMAP 2002).

Despite these steps, production of many toxic substances has not yet been controlled. The U.S. and Japan are major sources of dioxins and furans (AMAP 2002). Hexachlorobenzene concentrations in the arctic are unexplained, leading to the hypothesis that there are as yet unknown sources for this contaminant (AMAP 2002). Lindane and endosulfan are still in widespread use, and butyltin compounds are only partially regulated (AMAP 2002).

“New” chemicals that do or may have impacts similar to already regulated “legacy” chemicals are also cause for major concern. Polybrominated diphenyl ethers (“PBDEs”) are not regulated and their use has increased in the last decade, with an annual worldwide production of over 200,000 tons (AMAP 2002). In general, most chemicals on the market today have not been adequately tested to determine their impacts on wildlife (Walker 2004).

## V. OTHER REGULATORY SHORTFALLS

Because virtually all of Alaska’s Arctic Coastal Plain consists of wetlands, many components of oil and gas development such as roads, pads, causeways, gravel islands, gravel mines, and pipeline burial routes require permits pursuant to Section 404 of the US Clean Water Act (NRC 2003). Prior to 1979, however, the US Army Corps of Engineers (“Army Corps”), the federal agency responsible for Clean Water Act implementation, did not exercise its authority on Alaska’s Arctic Slope (NRC 2003). The Army Corps now asserts that it lacks jurisdiction over those “unpermitted” sites, and there is no detailed mapping or inventory of them (NRC 2003). Since 1979, the Army Corps has issued 1,179 permits for the Arctic Slope and has denied only three (NRC 2003). The Army Corps has no estimate of the total area affected by its Section 404 permitting program (NRC 2003). Overall, the Army Corps permitting program does not rigorously implement the Clean Water Act on Alaska’s Arctic Slope, and therefore this regulatory scheme provides minimal protection to the polar bear and its habitat. Regulation via the Clean Water Act has not limited the sprawling industrial infrastructure that has accompanied oil and gas development.

The US Congress exempted hazardous wastes produced as a result of oil and gas development from the provisions of the US Resource Conservation and Recovery Act, and therefore hazardous wastes produced by oil and gas companies and their subcontractors are not regulated through this important statute (NRC 2003). This regulatory gap is important as polar bears have been known to die from ingestion of oil and gas related toxic substances such as ethylene glycol (Lentfer 1990).

NRC (2003:93) cites “the lack of an effective, coordinated regulatory structure” for the lack of significant progress in restoring disturbed and contaminated sites on Alaska’s Arctic Slope. The lack of effective (or effectively implemented) regulatory regimes is also to blame for the failure to minimize or eliminate risks to the polar bear from oil, gas, and mineral development.

While the polar bear countries have various laws and regulations governing oil and gas development, none has prevented the spread of oil and gas activity into polar bear habitat, which is currently increasing and will continue to do so in the future. Moreover, while the US, Canada, and Norway all have rules requiring public disclosure and analysis of impacts to the environment including the polar bear, these analyses in practice do not adequately consider cumulative impacts to the polar bear, even when the impacts are happening in close proximity but across international borders. For example, neither the Canadian nor the US environmental documents analyzing oil and gas development in the Southern Beaufort Sea contain any analysis of any of the cumulative impacts of the other country's projects, including but not limited to impacts to polar bear denning and impacts from oil spills (MMS 2003 and 2004; Devon Canada Corporation 2004). This is despite the fact that both projects impact the same polar bear population, and the fact that the project area boundaries are quite close to one another. Consideration of cumulative impacts is critically important and will become even more so as global warming and other impacts to the polar bear advance. The failure of existing regulatory mechanisms to achieve a meaningful analysis of cumulative impacts, or to place any significant areas of polar bear habitat off limits to oil and gas development demonstrate that existing regulatory mechanisms are inadequate to protect the polar bear.

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A copy of all references cited in this Petition have been included on compact disk and submitted along with the Petition. Petitioner requests that the Secretary and the FWS consider these references in the development of the 90-day finding and all future determinations on the petitioned action. Several books and longer reports are not included on the compact disk, but presumably are already in the posession of FWS.

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