Exhibit A:

COSEWIC. 2008. COSEWIC assessment and update status report on the polar bear *Ursus maritimus* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa.

COSEWIC
Assessment and Update Status Report

on the

Polar Bear
Ursus maritimus

in Canada

SPECIAL CONCERN
2008

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

COSEWIC. 2008. COSEWIC assessment and update status report on the polar bear *Ursus maritimus* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa. vii + 75 pp.

Previous reports:

COSEWIC. 2002. COSEWIC assessment and update status report on the polar bear *Ursus maritimus* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa. vi + 29 pp.

Stirling, I., and M.K. Taylor. 1999. Update COSEWIC status report on the polar bear *Ursus maritimus* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa. 27 pp.

Stirling, I. 1991. Update COSEWIC status report on the polar bear *Ursus maritimus* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa. 24 pp.

Stirling, I. 1986. COSEWIC status report on the polar bear *Ursus maritimus* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa. 20 pp.

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COSEWIC
Assessment Summary

Assessment Summary – April 2008

Common name
Polar bear

Scientific name
Ursus maritimus

Status
Special Concern

Reason for designation
The species is an apex predator adapted to hunting seals on the sea ice and is highly sensitive to over harvest. Although there are some genetic differences among bears from different parts of the Arctic, movement and genetic data support a single designatable unit in Canada. It is useful, however, to report trends by subpopulation because harvest rates, threats, and, hence, predicted population viability, vary substantially over the species' range. Some subpopulations are over harvested and current management mostly seeks the maximum sustainable harvest, which may cause declines if population monitoring is inadequate. Until 2006, some shared subpopulations were subject to harvest in Greenland that was not based on quotas. Population models project that 4 of 13 subpopulations (including approximately 28% of 15,500 polar bears in Canada) have a high risk of declining by 30% or more over the next 3 bear generations (36 years). Declines are partly attributed to climate change for Western Hudson Bay and Southern Beaufort Sea, but are mostly due to unsustainable harvest in Kane Basin and Baffin Bay. Seven subpopulations (about 43% of the total population) are projected to be stable or increasing. Trends currently cannot be projected for 2 subpopulations (29% of the total population). Bears in some subpopulations show declining body condition and changes in denning location linked to decreased availability of sea ice. For most subpopulations with repeated censuses, data suggest a slight increase in the last 10-25 years. All estimates of current population growth rates are based on currently available data and do not account for the possible effects of climate change. The species cannot persist without seasonal sea ice. Continuing decline in seasonal availability of sea ice makes it likely that a range contraction will occur in parts of the species range. Decreasing ice thickness in parts of the High Arctic may provide better habitat for the bears. Although there is uncertainty over the overall impact of climate change on the species' distribution and numbers, considerable concern exists over the future of this species in Canada.

Occurrence
Yukon, Northwest Territories, Nunavut, Manitoba, Ontario, Quebec, Newfoundland and Labrador.

Status history
Designated Not at Risk in April 1986. Status re–examined and designated Special Concern in April 1991. Status re–examined and confirmed in April 1999, November 2002, and April 2008.

COSEWIC
Executive Summary

Polar Bear
Ursus maritimus

Species information

The polar bear (*Ursus maritimus* Phipps) evolved within less than 400,000 years to occupy the niche of hunting seals from a sea-ice platform. Many of the physical traits of polar bears can be viewed as adaptations to hunting arctic seals.

Distribution

Polar bears are a circumpolar species that occur in Canada from Yukon to Newfoundland and Labrador, and from northern Ellesmere Island south to James Bay. The population is distributed among 13 subpopulations with some evidence for genetic separation between them. The length and frequency of seasonal movements undertaken by bears within subpopulations varies with the size of the geographic area occupied, the annual pattern of freezing and break-up of sea ice, and availability of features such as land masses, multi-year ice, and polynyas. Distinctions between subpopulations or larger-scale divisions based on ecoregions are insufficient for status to be assigned to designatable units below the species level.

Habitat

The productivity of polar bear habitat is closely linked to the physical attributes of sea ice (type and distribution) and the density and distribution of ice-dependent seals, especially ringed seals (*Pusa hispida*). From early winter until break-up of annual sea ice in spring, polar bears are dispersed predominantly over sea ice along the coast. They may range >200 km offshore. Maternal denning sites are generally located on land near the coast, being excavated in snowdrifts and in some places frozen ground. Offshore maternal dens on multi-year ice floes are also known to occur, particularly in the western Canadian Arctic.

Biology

Reproductive rates vary among subpopulations of polar bears but all are relatively low. Females reach sexual maturity at 4–6 years and have litters of typically 1–2 cubs approximately every 3 years. Most males generally breed at 8–10 years. Few polar bears live longer than 25 years.

Population sizes and trends

Data on survival and reproduction suggest that 4 of 13 subpopulations (Western Hudson Bay, Southern Beaufort Sea, Baffin Bay, and Kane Basin), representing approximately 27.8% of the total population of 15,500 polar bears shared by Canada and its immediate neighbours (Greenland and the United States), are likely declining at the present time. Four subpopulations are most likely to be stable (including 1 slightly increasing and 1 possibly slowly declining) at the present time (comprising 29.3% of the total population), and 3 subpopulations are most likely to be increasing (13.5% of the total population). Trend cannot be reported due to pending analysis or lack of data for the 2 remaining subpopulations (29.4% of the total population). Estimates of possible declines over longer periods (e.g., 3 generations) are complicated by potential changes in survival and reproduction due to climate change and/or alterations in harvest management. Current declines are due to over harvest (Baffin Bay, Kane Basin) and climate change (Western Hudson Bay, Southern Beaufort Sea). Long-term population trends will ultimately be determined by changes in extent and types of sea ice associated with a warming climate in the Arctic.

Limiting factors and threats

The main, proximate limiting factors affecting polar bear distribution and numbers today are availability of food (access to and abundance of ice-dependent seals) and human-caused mortality (almost exclusively from hunting). Other potential limiting factors include intraspecific predation, pollution, especially that associated with offshore development of hydrocarbon reserves and increased ship traffic, and the accumulation of environmental contaminants (mainly organochlorines) in tissues of polar bears. Climate change is likely to influence all of the factors above and should thus be treated as the ultimate limiting factor to polar bears. If the climate continues to warm as projected by the Intergovernmental Panel on Climate Change (IPCC), all populations of polar bears will eventually be affected.

Special significance of the species

The polar bear is the only terrestrial carnivore to occupy the highest trophic level of a marine ecosystem. The polar bear is an icon of Canada's wildlife heritage, and is of great cultural significance to the Canadian people. Polar bears are also of cultural, spiritual, and economic significance to some northern native peoples. As a symbol of the pristine Arctic environment, polar bears are seen throughout the world as a barometer of important environmental issues, especially climate change and pollution. Canada has national and international responsibilities with respect to the study, management, and protection of polar bears, as outlined in the international *Agreement on the Conservation of Polar Bears*. This obligation is particularly important to our nation because we collectively manage 55–65% of the world's polar bears.

Existing protection or other status designations

In 2006, largely in response to the threat posed by global warming, the polar bear was moved from Least Concern-Conservation Dependent to the category of Vulnerable in the Red List of the Species Survival Commission (SSC) of the IUCN-The World Conservation Union, corresponding to the Threatened category of COSEWIC. This uplisting was based on an assessment of available data and the unanimous opinion of the IUCN/SSC Polar Bear Specialist Group. Polar bears are on Appendix II of CITES (Convention on International Trade in Endangered Species). Under CITES, any international shipment of polar bears or parts thereof requires a permit. The US Secretary of the Interior announced on May 14, 2008, that the polar bear will be listed as Threatened under the U.S. *Endangered Species Act.* Management authority for this species rests with the provinces, territories, and wildlife management boards established under land claims. Hunting is largely managed through quota systems and according to Aboriginal treaty rights. Internationally, the management of polar bears is coordinated under the *Agreement on the Conservation of Polar Bears*, signed by the federal government on behalf of all Canadian jurisdictions in November 1973. At the time of writing, habitat of polar bears is formally protected only through Canada's terrestrial system of national parks and Ontario's provincial park system; these protected areas encompass approximately 2.9% of the area of occupancy of the species in Canada. The majority of polar bear habitat is marine, for which there are no federal, provincial, or territorial protected areas.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2008)

Wildlife Species	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 is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment Canada
Canadian Wildlife Service

Environnement Canada
Service canadien de la faune

Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

Update
COSEWIC Status Report

on the

Polar Bear
Ursus maritimus

in Canada

2008

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1. INTRODUCTION

Canada has national and international responsibilities with respect to the study, management, and protection of polar bears. The international *Agreement on the Conservation of Polar Bears* (http://pbsg.npolar.no), signed by Canada, the United States, Norway, Denmark (on behalf of Greenland), and the U.S.S.R. (now Russia) on November 15, 1973, stipulates that management of polar bears shall be conducted "in accordance with sound conservation practices based on the best available scientific data." This obligation is particularly important to Canada because we collectively manage 55–65% of the world's polar bears. This document summarizes and updates our collective knowledge of the biology and status of the polar bear in Canada.

2. SPECIES INFORMATION

2.1 Name and Classification

Class Mammalia
Order Carnivora
Family Ursidae
Subfamily Ursinae
Scientific name *Ursus maritimus* Phipps (1774), no subspecies
Common names Polar bear, Ours blanc, Nanuk, Nanuq, Wapusk

Gentry (2001) provides an historical summary of the nomenclature of the polar bear. In brief, Linnaeus (1758, p. 47) first referred to the polar bear as "*Ursus maritimus albus-major*, *articus*," but he did not consider the polar bear as a distinct species from the brown bear (*Ursus arctos*). Phipps (1774, p. 185) was first to describe the polar bear as its own species. Gentry (2001) writes that, based on the rules of nomenclature, the appropriate authority and date of the specific name of *Ursus maritimus* is Phipps (1774) and not Linnaeus (1758), as is sometimes observed. Alternative generic names have included *Thalassarctos*, *Thalarctos*, and *Thalatarctos*; however, since the 1960s most authors have used the name *Ursus maritimus*.

2.2 Morphological Description

Polar bears are large ursids most comparable in size and shape to the brown bear, from which they differ because they lack the characteristic shoulder hump, have a smaller and less dish-shaped head, a longer rostrum, and an elongated neck. Compared to brown bears, the grinding surfaces of the cheek teeth of polar bears are more serrated, which is an adaptation to a more carnivorous diet. The claws of the polar bear are smaller and sharper than those of the brown bear, and the forepaws are enlarged making them useful for paddling in water, collapsing roofs of subnivian birth and haul-out lairs of seals, digging through or climbing on snow and ice, and dispatching seals. Unlike other bear species, pads of the paws of the polar bear are entirely furred, which may function to help insulate the feet or improve traction on ice and snow. Polar bear skin is black, which improves absorption of solar energy.

Translucent hair makes the pelage appear white, especially right after moulting, although it may appear yellow or off-white during summer. Fur of the polar bear will often reflect the colours of the sky and snow, which provides camouflage while hunting. Sexual dimorphism is pronounced. Male polar bears can weigh up to 800 kg and reach 2.8 m in length from nose to tail (DeMaster and Stirling 1981). Females are smaller, usually not exceeding 400 kg and 2.5 m (Amstrup 2003).

2.3 Evolution and Genetic Description

Fossil evidence suggests that polar bears evolved from brown bears sometime within the last 400,000 years (Thenius 1953; Kurtén 1964). This finding is supported by data on molecular genetics that suggests divergence of the species occurred as recently as 200,000–250,000 years ago. In particular, the polar bear has been linked to a clade of brown bears that occur today in the Alexander Archipelago of southeast Alaska (Cronin *et al.* 1991; Talbot and Shields 1996a,b). Cronin *et al.* (1991) reported that mitochondrial DNA (mtDNA) of polar bears and brown bears of the Alexander Archipelago differ by only 1%; however, divergence of more than 2.5% separates polar bears from brown bears occurring elsewhere. Brown bears are thought to have survived in refugia in the southern Alexander Archipelago during the Late Wisconsin glacial maximum of 20,000 years ago (Heaton and Grady 1993); however, since the polar bear evidently separated from this clade long before the first of the Wisconsin glaciations (commencing ca. 70,000 years ago), it is unlikely that polar bears evolved specifically in the Alexander Archipelago.

The close relationship between the polar bear and brown bear is highlighted by instances of hybridization in the wild (e.g., a hybrid bear was recently harvested near Banks Island; personal communication of Gau [2006]). Successful, interspecific matings in captivity have been observed for many years, with clear evidence of first- and second-generation fertility in offspring (Martin 1876, 1882; Kowalska 1962, 1965, 1969).

The molecular ecology of polar bears has most recently been studied by Paetkau *et al.* (1995, 1999), Crompton (2004), and Saunders (2005). As discussed in more detail in Section 3.3, there are varying degrees of genetic differences between most identified subpopulations of polar bears in Canada (Figures 1 and 2; Tables 1 and 2); however, these differences do not identify them as genetic subunits or subspecies. Paetkau (1999) states that, with respect to identified management subpopulations across the circumpolar range of the polar bear: “no genetic discontinuities [have been] found that would be consistent with evolutionarily significant periods of isolation between groups.”

Since the Late Pleistocene, notable morphological change has occurred in the polar bear. In particular, there has been a trend toward a decrease in body size, fossil polar bears being much larger than they are today (Kurtén 1964). Polar bears evolved to take advantage of killing seals from a sea-ice platform, particularly ringed seals (*Pusa hispida* [prior to 2003 was under the genus *Phoca*, see IUCN 2006]) and bearded seals (*Erignathus barbatus*). Many of the physical traits of polar bears can be viewed as adaptations to hunting arctic seals.

Figure 1. Circumpolar distribution of the polar bear. Abbreviations of delineated subpopulations include Viscount Melville Sound (VM), Norwegian Bay (NW), Kane Basin (KB), Lancaster Sound (LS), Baffin Bay (BB), Davis Strait (DS) Southern Hudson Bay (SH), Western Hudson Bay (WH), Foxe Basin (FB), Gulf of Boothia (GB), M'Clintock Channel (MC), Southern Beaufort Sea (SB), and Northern Beaufort Sea (NB). Source: IUCN/SSC Polar Bear Specialist Group (2006).

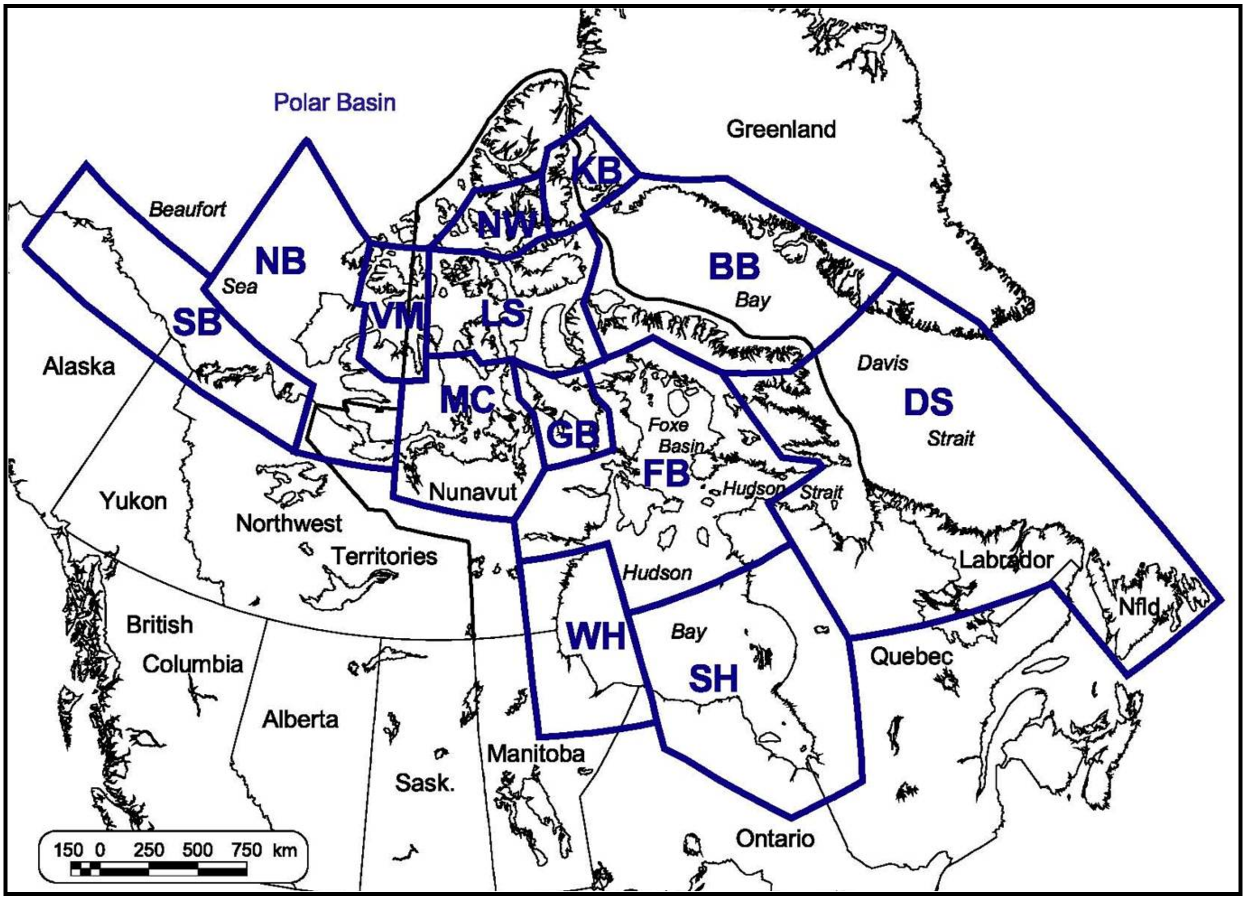

Figure 2. Canadian subpopulations of polar bears. Abbreviations of delineated subpopulations include Viscount Melville Sound (VM), Norwegian Bay (NW), Kane Basin (KB), Lancaster Sound (LS), Baffin Bay (BB), Davis Strait (DS) Southern Hudson Bay (SH), Western Hudson Bay (WH), Foxe Basin (FB), Gulf of Boothia (GB), M'Clintock Channel (MC), Southern Beaufort Sea (SB), and Northern Beaufort Sea (NB). Source: Taylor *et al.* (2001) and PBTC (2007).

3. DISTRIBUTION

3.1 Global Range

Polar bears are circumpolar in the northern hemisphere. Initially, polar bears were believed to occur as a single, homogeneous population that ranged throughout the circumpolar Arctic, with animals carried passively on sea ice by the predominant currents (Amstrup 2003). However, recent studies based on satellite telemetry and mark-recapture demonstrate that, although some movements may be exceptionally large (Messier *et al.* 2001), polar bears do not wander as nomads throughout the Arctic, but rather show seasonal fidelity to local areas (Taylor and Lee 1995; Bethke *et al.* 1996; Taylor *et al.* 2001). Today, the circumpolar distribution of the polar bear is usually divided into 19–20 "subpopulations" of which 13 (excluding bears of the Arctic Basin, which are at low density and thought to generally support transient bears) range into or are entirely contained within Canada (Figures 1–3; Taylor *et al.* 2001).

3.2 Canadian Range

In North America, the area of occupancy (Figure 3) of the polar bear extends from the southern edge of the permanent multi-year pack ice of the Arctic Ocean (Arctic Basin) to include sea ice and coastal areas of Greenland, the Canadian Arctic Archipelago, east to the Labrador coast, south to James Bay, and west to the Bering Sea. A few polar bears regularly appear as far south as the island of Newfoundland. Bears have occasionally been noted in the Gulf of St. Lawrence in years when thick pack ice drifts farther south than normal. These observations are included in the species' extent of occurrence (Figure 3). The present area of occupancy of the polar bear in Canada appears to correspond to the species' historic area of occupancy after the end of the last major glacial retreat (10,000 years ago), although some authors suggest that polar bears were more common in southern Labrador and Newfoundland in previous centuries than they are today (Smith *et al.* 1975; Stirling and Kiliaan 1980). Smith *et al.* (1975) communicates that early explorers commonly encountered polar bears in Newfoundland, and bears were sometimes observed in high densities in southern Labrador (e.g., a congregation of 32 bears observed by Cartwright in the 1770s feeding on salmon at the mouth of the Eagle River). Historic reductions in the abundance of polar bears in southern Labrador and Newfoundland may have been a consequence of several hundred years of human habitation and associated hunting, or a response to climate warming after climax of the cooling events commonly referred to as the "Little Ice Age," particularly the substantial glacial (and sea ice) advances in North America of 1711–1724 and 1835–1849 (Lamb 1977, p. 453).

3.3 Designatable Units

Delineation of subpopulations in Canada (Figure 2) has been largely based on hierarchical cluster analysis of movements of radio-collared females (Bethke *et al.* 1996; Taylor *et al.* 2001; Amstrup *et al.* 2004). Within most subpopulations, population dynamics appear to be determined from internal rates of birth and death (mainly from harvest, which is set at different levels according to subpopulation), rather than emigration/immigration, although annual rates of exchange between adjacent subpopulations range from 0.4–8.9% (Taylor *et al.* 2001). Genetic distances between sampled individuals from subpopulations based on F_{ST} (a correlation of allele frequencies between populations [Weir and Cockerham 1984]) suggest the possibility of 4 population clusters among identified subpopulations (Table 1 and Paetkau *et al.* 1999); however, misclassification rates in assignment tests among clusters and subpopulations (Table 2) do not support definitive boundaries in terms of genetic isolation across the range of the polar bear (Paetkau *et al.* 1999). Values of pairwise F_{ST} are low: among all Canadian subpopulations the highest observed difference in pairwise F_{ST} by Paetkau *et al.* (1999) was 0.091 (Southern Beaufort Sea vs. Foxe Basin), with a Canada-wide mean pairwise F_{ST} of 0.039 (Table 1). The latter is relatively small in comparison to mean pairwise F_{ST} data from other species of carnivores in North America, including populations of non-hybridizing gray wolves, *Canis lupus*, and coyotes, *Canis latrans* (0.168 and 0.107, respectively; Roy *et al.* 1994); grizzly bears in the central Rocky Mountains (0.096; Proctor *et al.* 2005), and wolverines, *Gulo gulo*

(0.067; Kyle and Strobeck 2001). When comparing individuals of pairs of widely separated subpopulations of black (*Ursus americanus*), brown, and polar bears, polar bears exhibited the lowest values of intraspecific genetic distance, D_{LR} (Figure 5 of Paetkau *et al.* 1997). Among adjacent potential subdivisions of polar bears identified in Paetkau *et al.* (1999; Table 1), F_{ST} differences of included subpopulations ranged from 0.024 to 0.061. The data of Paetkau *et al.* (1999) strongly support the hypothesis of a polar bear population that—despite the presence of regional differences in dynamics and environmental conditions—maintains considerable genetic interchange among subpopulations, with a gradation in genetic relatedness across the range. No localized adaptations have led to the genetic isolation of any subpopulation: identified units are not evolutionarily significant (Paetkau *et al.* 1999).

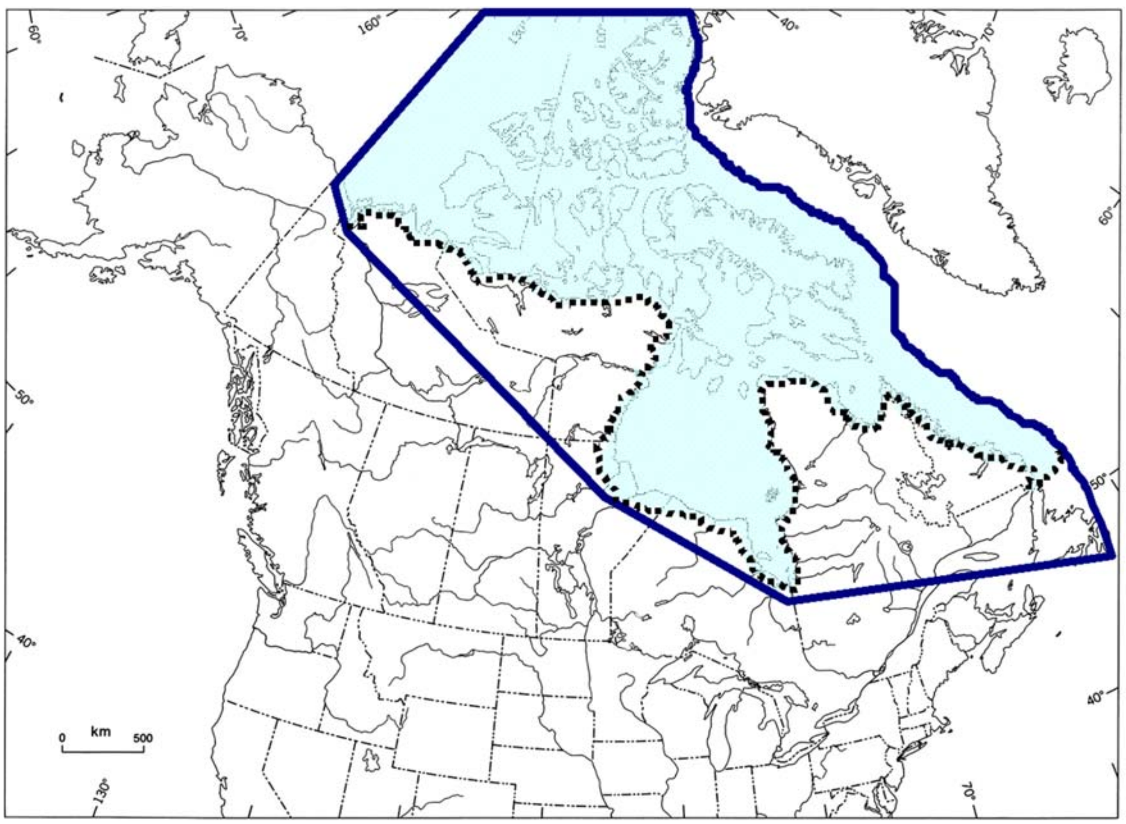

Figure 3. The extent of occurrence (bold polygon, 8.7 × 10^6 km^2) and area of occupancy (shaded region with dotted outline, 5.6 × 10^6 km^2) of polar bears in Canada (areas estimated using Lambert Equal-Area Azimuthal [North Pole] projection in ArcGIS, v. 9.1 [ESRI, 380 New York Street, Redlands, CA]). Note that these areas include all freshwater, ocean, and land in the computation of area. The extent of occurrence as defined by COSEWIC (COSEWIC's Assessment Process and Criteria, reviewed and approved by COSEWIC in April 2006) is: “the area included in a polygon without concave angles that encompasses the geographic distribution of all known populations of a species (up to and including the international border).” The area of occupancy is defined as the: “area within 'extent of occurrence' that is occupied by a taxon, excluding cases of vagrancy.”

Table 1. Genetic distances among Canadian and worldwide subpopulations of polar bears (see legend of Figure 2 for abbreviations for Canadian subpopulations) presented in Paetkau *et al.* (1999): F_{ST} (× 100) below diagonal, D_{LR} above. Rectangles highlight distances within 4 suggested population clusters by Paetkau *et al.* (1999). F_{ST} is a correlation of allele frequencies between populations (Weir and Cockerham 1984) and D_{LR} is the mean genotype log likelihood ratio across individuals from the 2 subpopulations (Paetkau *et al.* 1997). Source: table reprinted from Paetkau *et al.* (1999) and © 1999 Blackwell Science Ltd.

Canadian Subpopulations

	WH	FB	DS	BB	KB	LS	GB	MC	VM	NW	NB	SB	CS	FN	SV	EG
WH		0.5	1.4	3.9	3.6	3.9	3.5	5.2	4.4	4.3	5.4	5.9	6.6	5.6	5.0	5.9
FB	0.9		1.1	3.3	3.3	3.9	4.1	4.7	4.7	4.9	6.3	6.4	7.8	5.5	5.3	5.8
DS	2.1	1.4		1.6	2.1	2.6	2.4	2.7	3.0	3.4	3.7	4.6	4.9	3.1	3.2	3.8
BB	5.2	4.4	2.6		0.1	0.9	1.3	1.5	1.7	2.5	3.0	3.5	3.9	2.8	2.7	2.7
KB	5.6	4.8	3.6	0.3		1.1	1.5	1.7	1.7	2.2	2.7	3.3	4.0	3.0	2.3	2.2
LS	5.4	5.2	3.9	1.0	1.1		0.7	0.8	0.8	1.7	2.5	3.4	4.5	3.0	2.8	2.6
GB	4.8	5.1	3.6	1.4	2.1	1.0		1.1	1.3	2.6	2.5	2.8	3.8	2.8	3.0	3.1
MC	5.7	5.2	3.2	0.9	1.3	0.5	1.1		0.9	3.7	2.5	3.7	3.9	2.6	2.4	2.7
VM	6.1	6.3	4.3	1.9	2.4	1.7	1.9	0.8		2.2	1.6	2.3	3.6	2.5	2.6	2.5
NW	6.8	7.5	5.8	3.5	2.5	2.4	3.7	3.9	3.5		3.4	4.3	5.4	4.5	4.4	4.1
NB	8.1	8.9	6.5	3.8	3.8	3.9	3.3	2.7	2.6	5.2		0.5	0.9	1.3	1.0	1.3
SB	8.6	9.1	7.4	4.6	4.9	5.8	4.3	4.2	3.7	6.3	0.5		0.9	1.4	1.8	2.1
CS	9.5	10.8	8.2	5.3	6.0	6.8	5.1	5.0	5.5	7.9	0.8	1.0		1.2	1.1	1.9
FN	8.5	8.4	5.3	3.9	4.6	5.1	4.4	3.3	3.7	6.8	1.4	1.8	1.7		0.0	0.4
SV	7.6	7.9	5.3	3.1	3.2	4.1	3.9	2.5	3.5	5.9	1.0	2.2	1.3	0.2		0.4
EG	8.7	8.8	6.5	3.4	3.2	4.2	4.2	3.0	3.8	5.8	1.4	2.6	2.1	0.8	0.3	

Table 2. Results of the population assignment test of Paetkau *et al.* (1999) based on microsatellite analysis of individuals sampled from the world's subpopulations of polar bears (abbreviations defined in the legend of Figure 2 for Canadian subpopulations). Each row contains the samples from a study area (''subpopulation'') and the columns indicate the subpopulations to which these samples were ''assigned'' (in which their genotypes had the highest likelihood of occurring). For example, of polar bears captured in Davis Strait (DS), 13 animals were correctly assigned to that subpopulation unit by genetic analysis, whereas 17 individuals captured in Davis Strait were assigned to alternate subpopulations. The boxes present the 4 suggested population units by Paetkau *et al.* (1999), as in Table 1. Source: table reprinted from Paetkau *et al.* (1999) and © 1999 Blackwell Science Ltd.

Canadian Subpopulations

	WH	FB	DS	BB	KB	LS	GB	MC	VM	NW	NB	SB	CS	FN	SV	EG	Total
WH	**21**	6	5											1			33
FB	9	**16**	3	1	1												30
DS	1	5	**13**	4	2		2	1			1			1			30
BB			3	**13**	7	2	1	2					1	1		1	31
KB		1		9	**9**	2		2		4	1	1				1	30
LS			2	1	2	**10**	2	5	4	3				1			30
GB	1		1	4	2	3	**10**	3	3	2		1					30
MC			2			1	2	**7**	3								15
VM	1		2	1		4	2	1	**14**	1	4						30
NW	1	1		2	1	3	2		2	**17**				1			30
NB					1			1	1	1	**11**	6	6	1	1	1	30
SB							2		2		6	**11**	3	5		1	30
CS											1	7	**15**	4	1	2	30
FN	1			1				1	2		3	3	1	**8**	9	3	32
SV						1	1		2		1		1	5	**11**	9	31
EG					2				2	1	2	1	3	5	4	**11**	31

Interchange among identified subpopulations is further suggested by recent Aboriginal Traditional Knowledge (ATK, Keith 2005; Nirlungayuk 2008) and results of independent genetic analyses (Crompton 2004, Saunders 2005). For example, using 9 microsatellite loci Saunders (2005, p. 39) found no support for any genetic discontinuities between M'Clintock Channel and Gulf of Boothia. Crompton (2004) additionally concluded that the subpopulation boundaries of Western Hudson Bay, Foxe Basin, and Davis Strait (Figure 2) were not supported by her study; rather, Crompton suggested that polar bears of the Hudson Bay region are structured into at least three breeding groups in the southern portion of Hudson Bay and what appears to be one larger admixed population to the north. Interchange of individuals between the subpopulations of the Southern Beaufort Sea and Northern Beaufort Sea (as currently defined; Figure 2) is also known to be considerable (Amstrup *et al.* 2004).

At a larger scale, Thiemann *et al.* (In press) recently argued that the population of polar bears in Canada should be divided by COSEWIC into 5 Designatable Units for conservation purposes. The argument for 5 units by Thiemann *et al.* (In press) is based partly on the results of Paetkau (1999) but also on differences in diet and ice conditions among subpopulations. The proposed units are identical to the 4 subpopulation clusters of Paetkau *et al.* (1999) as indicated in Table 1, with the exception that Davis Strait is separated from all other subpopulations because of differences in ecological conditions (principally higher abundances of harp seals in the region). Amstrup *et al.* (2007), using models of seasonal patterns of ice distribution and movements, similarly proposed regional ecoregions for polar bears for modelling purposes. The ecoregions of Amstrup *et al.* (2007) differ in several respects from the Designatable Units proposed by Thiemann *et al.* (In press), with boundaries appearing between the Northern and Southern Beaufort Sea subpopulations but not Norwegian Bay and those of the Canadian Arctic Archipelago, and pooling subpopulations with near complete loss of sea ice in summer (Baffin Bay, Davis Strait, and subpopulations of Hudson Bay are grouped together in Amstrup *et al.* [2007]).

Although useful for describing local trends in population growth, demographic parameters, behaviours, and managing polar bears, identified subpopulations cannot be considered Designatable Units as per COSEWIC guidelines (Appendix F5, COSEWIC Operations and Procedures Manual, last reviewed and approved by COSEWIC in 2005). Further, despite the arguments of Thiemann *et al.* (In press), the presence of larger-scale regional subdivisions in the polar bear population do not warrant more than a single Designatable Unit in Canada. However, this does not mean that conservation threats to polar bears are uniform across the range of the species. Because of this, and given historical management of the species on a subpopulation-by-subpopulation basis using bounds presented in Figure 2 (including different harvest rates), trends in the Canadian polar bear population are generally discussed in this report according to identified subpopulations (see Section 7).

4. HABITAT

4.1 Habitat Requirements

The physical attributes of sea ice are the primary determinants of the quality of polar bear habitat. Changes in sea ice and associated snow cover affect light transmission and thermodynamic processes important to lower trophic levels of the arctic marine ecosystem (Welch *et al.* 1992; Barber *et al.* 1995), which, combined with kinematic or topographic characteristics of sea ice, influence the distribution of ringed seals (Stirling and Lunn 1997; Barber and Iacozza 2004). In the Canadian Arctic, polar bear habitat is closely associated with that of the ringed seal (Stirling and Øritsland 1995) and includes areas of consolidated pack ice, areas immediately adjacent to pressure ridges, between multi-year and first-year ice floes, and at the floe edge between marginal and landfast sea ice (Stirling *et al.* 1982; Kingsley *et al.* 1985; Stirling and Derocher 1993; Stirling *et al.* 1993; Ferguson *et al.* 2000a). Seals are hunted through breathing holes, in birth lairs, or when hauled out on ice (Stirling and Archibald 1977; Smith 1980). Bearded seals, harp seals (*Pagophilus groenlandica*), spotted seals (*Pusa largha*), hooded seals (*Cystophora cristata*), walrus (*Odobenus rosmarus*), beluga whales (*Delphinapterus leucas*), and narwhal (*Monodon monoceros*) also feature in the diet of polar bears (Stirling and Archibald 1977; Kiliaan and Stirling 1978; Fay 1982; Lowry *et al.* 1987; Calvert and Stirling 1990; Smith and Sjare 1990; Derocher *et al.* 2002); however, scientific knowledge and ATK suggest it is the young ringed seal hunted at its subnivian den that is most important to the majority of polar bears (Stirling and Archibald 1977; Smith 1980; McDonald *et al.* 1997). Ringed seals, which live exclusively in association with sea ice for at least part of the year (as do bearded and harp seals), have apparently been the principal prey of polar bears for much of their co-evolutionary history, and many ringed seal behaviours appear to be adaptations to avoid predation by polar bears (Stirling 1977; Amstrup 2003). Changes in the distribution of ice-dependent phocids in response to climate warming is certain to impact the distribution of polar bears (Stirling and Derocher 1993; Barber and Iacozza 2004; Derocher *et al.* 2004).

Because the sea ice provides access to their main prey species, the distribution of polar bears in most areas changes with the seasonal extent of sea-ice cover. Amstrup *et al.* (2007) and Durner *et al.* (2007) discuss the different types of ice used and preferred by polar bears, including ecoregions described by divergent, convergent, archipelago, and seasonal ice conditions. Throughout the polar basin and into the Canadian Arctic Archipelago, polar bears spend their summers concentrated along the edge of the persistent pack ice. Significant northerly and southerly movements appear to be dependent on seasonal melting and refreezing of ice near shore (Amstrup *et al.* 2000). In other areas (Hudson Bay, Foxe Basin, Baffin Bay, Davis Strait, Hudson Bay, James Bay, and portions of the Canadian High Arctic) polar bears are forced onto land (summer retreat areas) for several months during the open water season while they wait for new ice to form (Amstrup *et al.* 2007).

If forced on land for summer due to lack of sea ice (50–60% of the Canadian population), polar bears vary in their habitat selection, often by sex and age group, with males displacing females and cubs inland and away from the coast (Stirling *et al.* 2004). Food may not be consumed, and bears may rely entirely on fat reserves (Derocher and Stirling 1990). In some areas (e.g., northeast Manitoba, Derocher *et al.* 1993; Davis Strait, M.K. Taylor, Department of Environment, Government of Nunavut, pers. obs.), polar bears have been observed to feed on blueberries (*Vaccinium uliginosum*) and crowberries (*Empetrum nigrum*). On occasion, polar bears may also depredate nests of waterfowl (e.g., Smith and Hill 1996) and have been observed to kill caribou (e.g., Derocher *et al.* 2000; Brook and Richardson 2002). In Labrador, feeding on salmon by bears has also been observed (Brazil and Goudie 2006). Whale carcasses attact large numbers of bears during the open-water season (Kalxdorff 1997; Perham 2005). The attraction of bears to garbage during the ice-free season is of major concern to the management of polar bears and human safety in the Arctic (Lunn and Stirling 1985). As the ocean freezes again in late autumn, bears that were trapped on land redistribute themselves throughout subpopulation ranges, except for pregnant females, which excavate maternity dens (Section 5.1).

4.2 Trends in Habitat

Trends in habitat as they relate to the status of polar bears focus on impacts of climate warming, particularly spatial and temporal trends in the types and extent of sea ice, including length of the open-water season. Climate-change-related trends in conditions of terrestrial habitat, including denning habitat (e.g., Obbard and Walton 2004), must also be taken into consideration; however, effects of climate warming on conditions of sea ice are most important to the status of the species. Climate change is modifying the dynamics of sea ice formation and distribution in the Arctic, and it is expected that amounts of multi-year sea ice will be reduced and that ice will continue to trend toward a predominance of thinner, annual ice formations. These changes are widely documented by both western science and through ATK. Several sources highlighting ATK of polar bears report Inuit concerns about deterioration of sea ice conditions and their impact on polar bears (Atatahak and Banci 2001; Dowsley 2005; Keith *et al.* 2005; NTI 2005; Nirlungayuk 2008). These conditions include the disappearance of multi-year ice and icebergs, which polar bears use as feeding and resting platforms. Other changes include thinner ice, more rough ice, and earlier spring break-up, which may reduce polar bear hunting efficiency.

The literature on climate change and loss of sea ice is constantly being updated, and this report presents only the most relevant summary results at the time of writing. The largest and most recent effort to summarize scientific observations of changes in sea ice in the Arctic was conducted by Lemke *et al.* (2007) in their collaborative chapter as part of the 2007 report of the Intergovernmental Panel on Climate Change (IPCC). Briefly, satellite data indicate a 2.7 ± 0.6% per decade decline in annual mean arctic sea ice extent observed since 1978. The decline for summer extent is larger than for winter in the Arctic, with the summer minimum declining at a rate of 7.4 ± 2.4% per decade since 1979. Some data indicate that the summer decline began around 1970. Submarine-derived data for the central Arctic indicate that the average thickness of sea ice in the central Arctic has very likely decreased by up to 1 m from 1987 to 1997. Model-based reconstructions support this, suggesting an arctic-wide reduction of 0.6 to 0.9 m over the same period. Large-scale trends prior to 1987 are ambiguous. In Western Hudson Bay, where variables of climate warming have recently been used to explain variation in survival rates of polar bears (Regehr *et al.* 2007a; see also below and Sections 6.1 and 7.10), analyses of regional climate data have shown that between 1950 and 2000, mean air temperatures in April, May, and June have warmed at a rate of 0.3–0.8°C per decade (Skinner *et al.* 1998; Gough *et al.* 2004; Ferguson *et al.* 2005; Gagnon and Gough 2005a,b). For example, April–May temperatures increased from a mean of -12.4°C in 1962 to -9.8°C in 2000 (Ferguson *et al.* 2005). From 1979 to 2004, spring break-up as measured from ice concentrations (50% ice: 50% water) shifted from late June to late May, an average change of -0.75 ± 0.25 (mean ± 1 SE) days earlier each year (Stirling and Parkinson 2006). Stirling and Parkinson (2006) demonstrated similar trends in earlier timing of break-up for Foxe Basin (-0.58 ± 0.19 days/year), Baffin Bay (-0.66 ± 0.20 days/year), and Davis Strait (-0.64 ± 0.69 days/year). In the above areas, almost all sea ice normally disappears during summer (Figure 4). For areas where ice persists in concentrations detectable from satellite imagery throughout the entire year (Figure 4), changes in ice concentrations (measured as minimum ice concentrations in summer) have been greatest in the Beaufort Sea and Gulf of Boothia and least in the central Arctic Archipelago (Parkinson and Cavalieri 2002; Comiso and Parkinson 2004).

Scientific projections of effects of climate change on sea ice in the Arctic vary—sometimes widely—and so we recommend that model-averaged projections, such as those presented by the 2007 report of the IPCC and 2004 Arctic Climate Impact Assessment (ACIA), be used to anticipate effects of climate change on the distribution and abundance of polar bears. Projected changes in sea ice in the Arctic as outlined by the IPCC are presented in the chapter of Christensen *et al.* (2007). In summary, the Arctic is very likely to continue to warm during this century in most areas, and the annual mean warming is very likely to exceed the global mean warming. There will be an increase of 5°C in annual temperature from now to the end of the 21st century (as estimated by the MMD-A1B ensemble mean projection of the IPCC); however, there is a considerable across-model range of 2.8°C to 7.8°C. Warming is projected to be greatest in winter and smallest in summer. Annual arctic precipitation is also very likely to increase in winter. Arctic sea ice is very likely to continue to decrease in extent and thickness, but it is uncertain how circulation patterns in the Arctic Ocean might change.

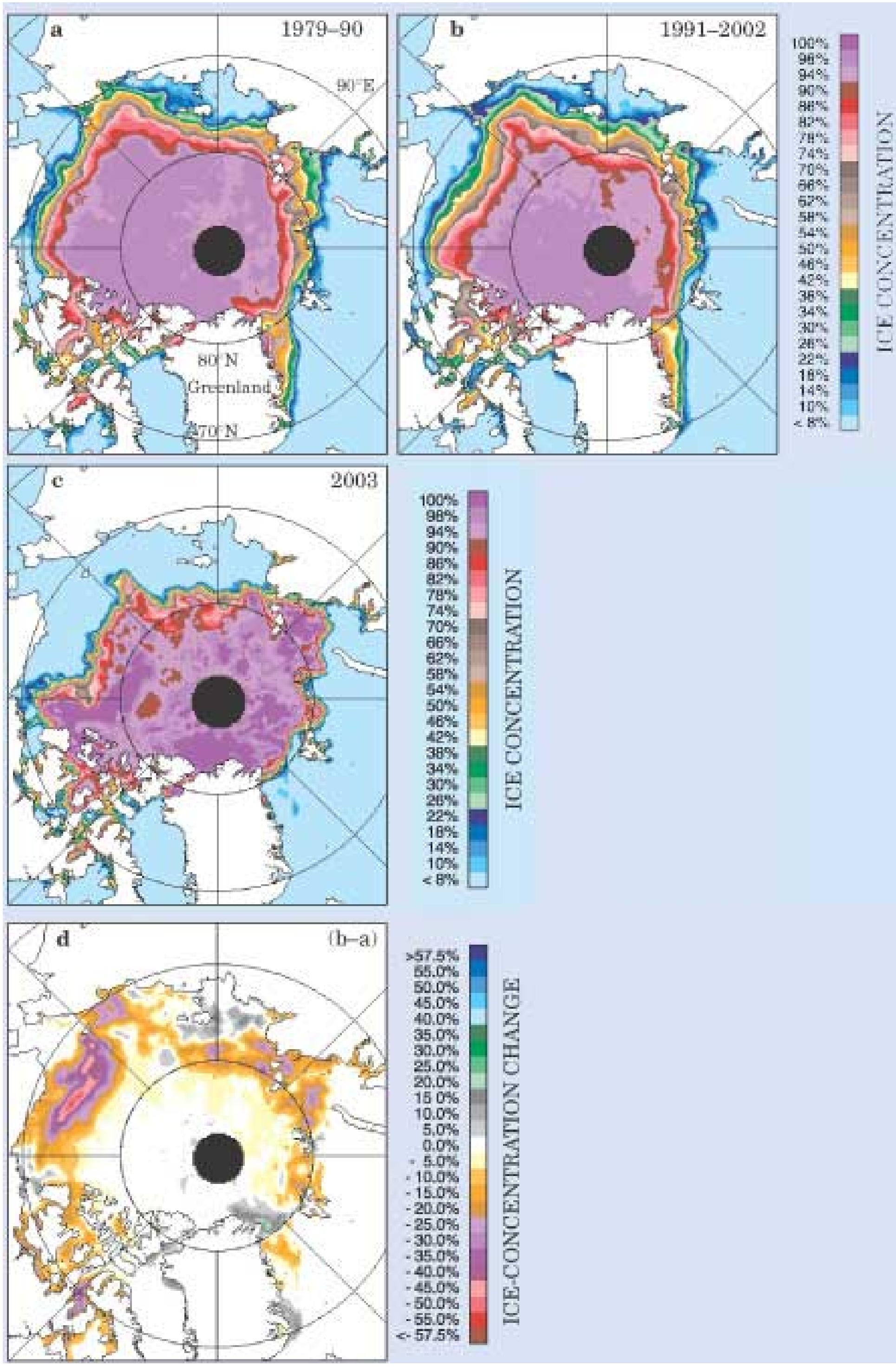

Figure 4. Ice concentrations at their minimum extents in summer recorded over a 24-year span. Panels a and b display the average minima recorded during the years 1979−90 and 1991−2002, respectively. Panel c shows the minimum concentration recorded in 2003. Ice concentrations are measurable down to 8%, below which it is impossible to discriminate between open water and ice-covered areas. Panel d, the difference between the first 2 panels (b − a), reveals the changes between the 2 periods. The average size of the ice pack in 1979−90 is greater than that in 1991−2002 by about 12%. Source: reproduced from Comiso and Parkinson (2004) and © 2004 the American Institute of Physics.

Model-averaged projections of change in extent of sea ice are most often presented as anticipated changes in the minimum extent of sea ice that occurs in late summer (September) in the Arctic. Projected changes in the extent of summer sea ice are presented in Figure 5, which are model-averaged projected changes reproduced from ACIA (2004). Changes in extent of sea ice have varied and will continue to vary regionally in Canada, and it is anticipated that the monthly extents of sea ice will show the least rates of change within the Arctic Archipelago and the greatest rates of change in Hudson Bay, Foxe Basin, Baffin Bay, Davis Strait, and the Beaufort Sea. Nonetheless, ACIA model-averaging indicates that by 2090 it is likely that almost all sea ice within Canada will form only as annual (winter) sea ice (Figure 5).

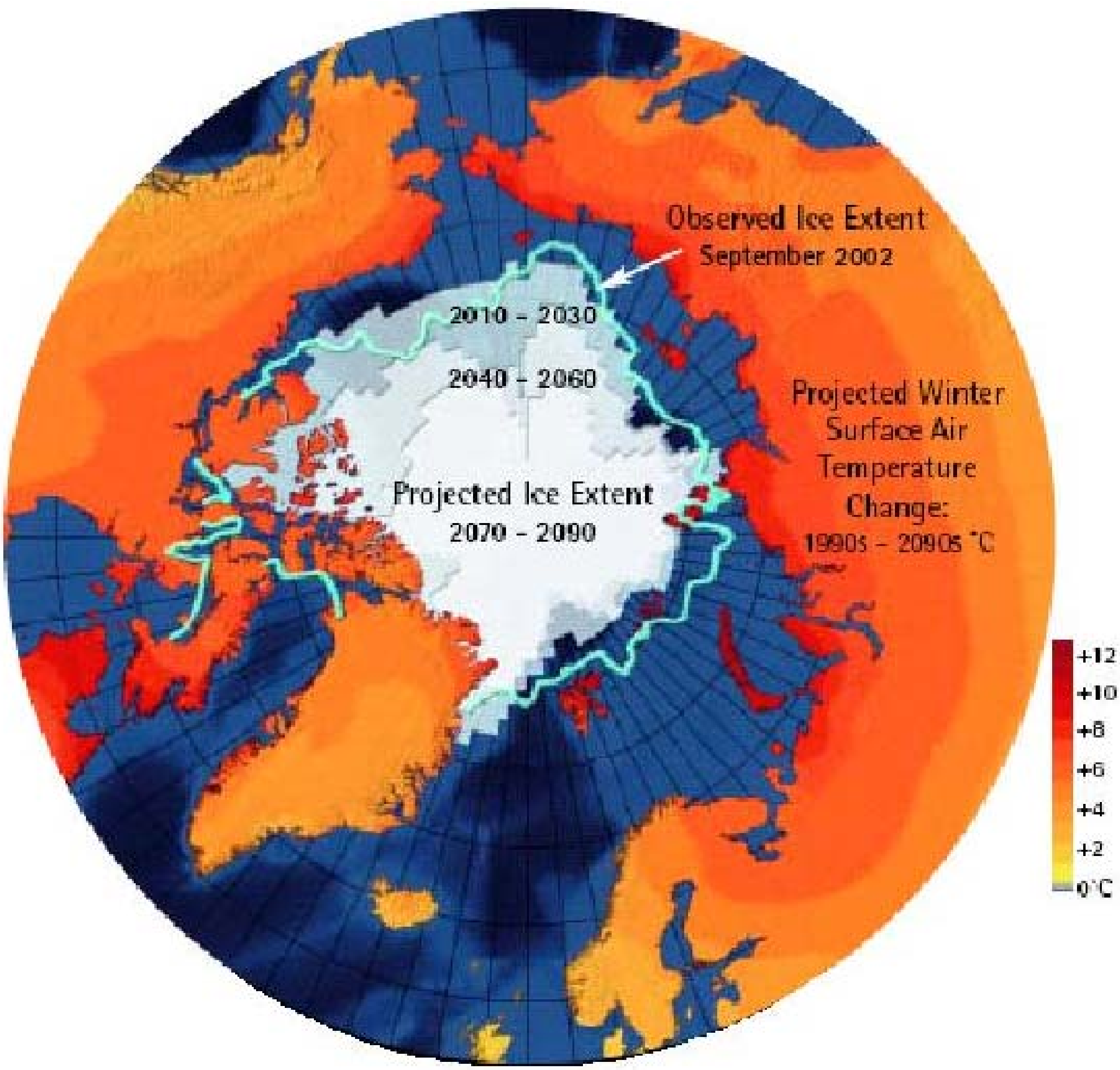

Figure 5. Current and model-averaged projected decreases in extent of sea ice in September as presented by ACIA (2004). Source: ACIA (2004) and © Arctic Climate Impact Assessment.

Higher temperatures and loss of sea ice in the Arctic do not bode well for the future of polar bears. However, quantitative data on what trends in habitat mean for the future distribution and abundance of polar bears are limited. In particular, there is a lack of data on how the dependent variables of projection models produced by bodies like the ACIA and IPCC (e.g., temperature, precipitation, summer extent of sea ice) relate as predictors of survival and reproduction (and thus abundance and distribution) of polar bears. As vital rates will likely relate to variables of climate change in a non-linear manner, depending not only on location (northern subpopulations may initially benefit from reductions in less-productive, multi-year sea ice) but also important factors such as density of prey species, it is difficult to objectively predict population trends into the future from data on climate warming alone. For example, inferring demographic implications for polar bears from changes in extent of summer sea ice is problematic because total or near total melting of sea ice that forces bears onshore in summer is the normal situation faced by approximately 50–60% of the polar bear population in Canada.

What is needed are data that link demographic rates to changes in sea ice. At the time of writing this report, four empirical studies have attempted to correlate annual ice conditions with survival rates of polar bears: studies in the Western Hudson Bay (Regehr *et al.* 2007a; Section 6.1 and 7.10); Southern Hudson Bay (Obbard *et al.* 2007; Section 7.11); Southern Beaufort Sea (Regehr *et al.* 2006, 2007b; Section 7.2); and Northern Beaufort Sea (Stirling *et al.* 2007; Section 7.3). The analyses for Western Hudson Bay and the Southern Beaufort Sea report links between survival of polar bears and conditions of sea ice; the studies for the Northern Beaufort Sea and Southern Hudson Bay found no environmental or body condition correlates of interannual variation in polar bear survival.

Although there is a general lack of data on the subject (in part due to the lengthy periods of study needed to build accurate models), there have been efforts (Amstrup *et al.* 2007; Durner *et al.* 2007) to forecast polar bear abundances based on projected changes in sea ice. Due to lack of data on carrying capacity in relation to ice conditions these projections are preliminary, but noteworthy because they are alarming: Amstrup *et al.* (2007) predict the loss of 2/3 of the world's polar bears in 45 years (for Canada, complete extirpation or severe depletion of polar bears from Baffin Bay, Davis Strait, Foxe Basin, Western Hudson Bay, Southern Hudson Bay, and the Southern Beaufort Sea). Amstrup *et al.* (2007) is a Bayesian network model combining "empirical data, interpretations of data, and [Amstrup's] professional judgment into a probabilistic framework." Durner *et al.* (2007) models the projected disappearance of preferred polar bear habitat (using well-constructed resource selection functions) in the polar basin (in Canada, affected populations would include polar bears of the Southern and Northern Beaufort Sea). Although "less available habitat will likely reduce polar bear populations, exact relationships between habitat losses and population demographics remain unknown (Durner *et al.* 2007)." Like Population Viability Analysis (PVA; Section 7), the outputs of these models depend on inputs and assumptions. We further discuss the importance of trends in habitat (climate warming) to the status of polar bears in Sections 5–7 and Section 9.

4.3 Habitat Protection

Canada's *Oceans Act* of 1996 allows for the establishment of Marine Protected Areas to conserve marine habitat for polar bears; however, there are no National Marine Conservation Areas in the Arctic at present. Hence, there is no formal protection of the vast majority of polar bear habitat in Canada. Some protection of terrestrial habitat important to polar bears is afforded through Canada's national parks and Ontario's provincial parks, and National Wildlife Areas. The north shore of Ivvavik National Park (9,750 km^2) offers protection of denning and onshore habitat for polar bears of the Southern Beaufort Sea. Tuktut Nogait National Park (16,340 km^2) offers limited protection to habitat of bears of the Northern Beaufort Sea because it is largely removed (by approximately 20 km) from the coast of Amundsen Gulf. Large protected areas in the Canadian Arctic Archipelago include Aulavik National Park (12,274 km^2) in the Northwest Territories and Auyuittuq (19,707 km^2), Sirmilik (22,200 km^2), and Quttinirpaaq (37,775 km^2) National Parks in Nunavut, and the National Wildlife Areas of Polar Bear Pass (2,624 km^2) on Bathurst Island and Nirjutiqavvik (1,650 km^2) off southern Ellesmere Island (Coburg Island). The newly announced Torngat Mountains National Park Reserve (9,600 km^2) in Labrador will protect a limited amount of terrestrial habitat for polar bears of Davis Strait. Parks specifically designated to protect denning and onshore habitat of polar bears in Hudson Bay include Wapusk National Park in Manitoba (11,475 km^2) and Polar Bear Provincial Park (23,552 km^2) in Ontario. Maternity denning occurs in the Cape Tatnam and Cape Churchill Wildlife Management Areas, Manitoba, and both of these regions have management plans under development that will control access to maternity denning areas. All formally protected areas within the range of the polar bear in Canada encompass approximately 2.9% of the area of occupancy of the species (Figure 3).

5. BIOLOGY

5.1 Life Cycle and Reproduction

The reproductive capability of polar bears varies among subpopulations. Age at first reproduction may be as early as 4 years, with most subpopulations having females producing litters at relatively high rates by age 6 (Table 3). The latest age at first reproduction is near the northern extreme of the species' range (Table 3) in Kane Basin (age 6) and Norwegian Bay (age 7).

Male polar bears likely become physiologically mature at 5–6 years of age. Fully formed spermatozoa appear only in low concentrations in testes of bears aged 2–4 years; concentrations asymptote at 5.8 years of age (Rosing-Asvid *et al.* 2002). Despite physiological maturity, younger males are not likely to reproduce because older males (if they are around) prevent them from doing so. Saunders (2005) recently demonstrated using paternity analysis that older adult male bears sire a disproportionate number of cubs compared to their representation in the population. It appears that most males do not enter the reproductive segment of the population until they are 8–10 years old (Ramsay and Stirling 1988; Derocher and Stirling 1998; Saunders 2005).

Table 3. Estimated means (and standard errors [SE] in parentheses) of post-den-emergence litter size and age-specific probabilities of litter production (LPR) for lone females or females with dispersing (2-year-old) cubs (because of the 3-year reproductive cycle of polar bears, females with cubs-of-the-year or yearlings are not available to mate and are not included in the LPR computation). Recruitment data have yet to be reported for remaining subpopulations.

Subpopulation (primary data source)	Cub (age 0) litter size	Age 4 LPR	Age 5 LPR	Age 6 LPR	Age 7+ LPR
Baffin Bay (Taylor *et al.* 2005)	1.587 (0.073)	0.096 (0.120)	0.881 (0.398)	1.000 (0.167)	1.000 (0.167)
Gulf of Boothia (Taylor *et al.* 2008c)	1.648 (0.098)	0.000 (0)	0.194 (0.178)	0.467 (0.168)	0.965 (0.300)
Kane Basin (Taylor *et al.* 2008a)	1.667 (0.083)	0.000 (0)	0.000 (0)	0.357 (0.731)	0.978 (0.085)
Lancaster Sound (Taylor *et al.* 2008b)	1.688 (0.012)	0.000 (0)	0.107 (0.050)	0.312 (0.210)	0.954 (0.083)
M'Clintock Channel (Taylor *et al.* 2006)	1.680 (0.147)	0.000 (0)	0.111 (0.101)	0.191 (0.289)	0.928 (0.334)
Northern Beaufort Sea (PBTC 2007)	1.756 (0.166)	0.118 (0.183)	0.283 (0.515)	0.883 (0.622)	0.883 (0.622)
Norwegian Bay (Taylor *et al.* 2008b)	1.714 (0.081)	0.000 (0)	0.000 (0)	0.000 (0)	0.689 (0.534)
Southern Beaufort Sea (Regehr *et al.* 2006)[a]	1.750 (0.170)	0.000 (0)	0.470 (0.090)	0.470 (0.090)	0.470 (0.090)
Southern Hudson Bay (PBTC 2007)[b]	1.575 (0.116)	0.087 (0.202)	0.966 (0.821)	0.967 (0.022)	0.967 (0.022)
Viscount Melville (Taylor *et al.* 2002)	1.640 (0.125)	0.000 (0)	0.623 (0.414)	0.872 (0.712)	0.872 (0.712)
Western Hudson Bay (IUCN/SSC 2006 and PBTC 2007)[c]	1.540 (0.110)	0.000 (0)	0.257 (0.442)	0.790 (0.180)	0.790 (0.180)

[a] No mean LPR for an age category is presented in Regehr *et al.* (2007b). Selected values provided by E. Regehr (USGS, Alaska Science Centre, Anchorage, AK) for the 2007 meeting of the PBTC.
[b] Also presented in IUCN/SSC Polar Bear Specialist Group (2006).
[c] Data presented in Table 3 of IUCN/SSC Polar Bear Specialist Group (2006), updated online version only.

Females enter estrus in March, which lasts until June and peaks in late April and early May (Palmer *et al.* 1988; Amstrup 2003). Ovulation is induced by coitus (Wimsatt 1963; Ramsay and Dunbrack 1986), and implantation is delayed until October (Palmer *et al.* 1988). Pregnancy rates appear to vary markedly among subpopulations, with as few as 50% of adult females (>5 years) that are available to mate (i.e., having no cubs or cubs that are about to be weaned) producing cubs the following year (e.g., Kane Basin; Table 3) to as many as 100% (Baffin Bay; Table 3).

Pregnant females enter maternity dens in late October and the young, normally 1-2, are born between November and early January (Harington 1968; Derocher *et al.* 1992); however, according to Inuit traditional knowledge, the timing of parturition varies with latitude. Dens are generally excavated in snow (although dens in frozen earth and peat are common in the south [Clark *et al.* 1997]), and are then covered and closed by snowdrifts. They are frequently located on islands or land in close proximity to the coast and adjacent to areas with high seal densities in spring (Harington 1968; Brice-Bennett 1977, Stirling and Andriashek 1992; Messier *et al.* 1994; Kalxdorff 1997; Ferguson *et al.* 2000b; Van de Velde *et al.* 2003; Lewis *et al.* 2006), although in Ontario and Manitoba polar bears may den up to 120 km inland at traditional denning areas (Kolenosky and Prevett 1983; Ramsay and Stirling 1990; Lunn *et al.* 2004; Richardson *et al.* 2005). Amstrup and Gardner (1994) observed that in the Beaufort Sea maternal dens on drifting pack ice were common, although this would be unusual for polar bears throughout much of the Canadian Arctic. All dens on sea ice observed by Messier *et al.* (1994) and Ferguson *et al.* (2000b) were classified as temporary shelter dens, rather than maternity dens. Fischbach *et al.* (2007) recently observed that in the Southern Beaufort Sea, the proportion of dens on the pack ice declined from 62% (1985–1994) to 37% (1998–2004) and that this change was related to changes and reductions in sea ice.

At birth, cubs weigh approximately 0.6 kg. They are nursed inside the den until sometime between the end of February and the middle of April, depending on latitude. By this time, cubs weigh 10–12 kg (Ramsay and Stirling 1988; Derocher and Stirling 1995a). As observed for brown bears (Ferguson and McLoughlin 2000), litter size varies little according to subpopulation (Table 3).

Lentfer *et al.* (1980) and Taylor *et al.* (1987) estimated an average interlitter interval of approximately 3.6 years. The exception is Western Hudson Bay where, in the early 1980s, up to 40% of females weaned their young at 1 year of age (Ramsay and Stirling 1988), although this proportion has declined since then (Derocher and Stirling 1995a).

Generation length in polar bears has been poorly studied, despite the variable being key to identifying categories of risk by bodies such as the IUCN/SSC and COSEWIC (i.e., likelihoods of decline over 3 generations). The IUCN/SSC Polar Bear Specialist Group (2006: p. 31) used 15 years as generation length: “calculated from the age of maturity (five years) plus half the length of the reproductive period in a complete life cycle (10 yrs; = 0.5 x 20 yrs).” COSEWIC identifies generation length as: “the average age of parents of a cohort (i.e. newborn individuals in the population).” Data on the average age of female polar bears with cubs-of-the-year in spring in a random sample of bears of all ages have seldom been reported. The paper of Regehr *et al.* (2006) allows us to compute this variable for bears of the Southern Beaufort Sea (from proportions presented in Table 3 of Regehr *et al.* [2006]). For the period 1967–1989, and conservatively assuming all bears in the age 20+ category were 25 years old, the mean age of females with newborns was 9.9 years. For 1990–2006 the average was 11.7 years. In Western Hudson Bay, the age-specific female mortality data of Regeher *et al.* (2007) suggest an average age of 12.7 years for females aged 5 years and older. This report will use 12 years as the generation time of polar bears.

Like other ursids, polar bears experience relatively high survival rates, and survival can generally be distinguished based on age or stage of life history. Generally, researchers assess survival rates separately for cubs-of-the-year (COYs), yearlings and subadults (ages 1–4), prime-age adults (ages 5–20), and senescent adults (ages 21+). Maximum age is often considered to be 30 years for bears in the wild, although lifespans longer than this are purported to be common in captivity. The general pattern is for COYs and yearlings to exhibit survival rates that are lower than subadults and prime adults, and senescent adults have lower survival rates than prime adults. Total survival rates (Table 4) are distinguished from natural survival rates (Table 5), which are computed by considering the fates of bears that die only of natural causes. Males often have lower total survival rates than females, due to purposeful sex-selectivity in the harvest and a greater propensity for males to become problem animals.

Table 4. Mean (SE in parentheses) of total (i.e., harvested) annual survival rates for age and sex classes of subpopulations of Canadian polar bears. No other subpopulations have reported total survival rates.

Subpopulation (primary data source)	Males					Females				
	Total Survival					Total Survival				
	0	1	2–4	5–20	>20	0	1	2–4	5–20	>20
Baffin Bay (Taylor *et al.* 2005)	0.538 (0.094)	0.879 (0.049)	0.879 (0.049)	0.923 (0.024)	0.874 (0.062)	0.600 (0.096)	0.901 (0.045)	0.901 (0.045)	0.940 (0.021)	0.913 (0.047)
Gulf of Boothia (Taylor *et al.* 2008c)	0.817 (0.201)	0.875 (0.085)	0.875 (0.085)	0.935 (0.040)	0.935 (0.040)	0.817 (0.201)	0.875 (0.085)	0.875 (0.085)	0.935 (0.040)	0.935 (0.040)
Kane Basin (Taylor *et al.* 2008a)	0.308 (0.172)	0.617 (0.180)	0.617 (0.180)	0.957 (0.046)	0.957 (0.046)	0.374 (0.180)	0.686 (0.157)	0.686 (0.157)	0.967 (0.043)	0.967 (0.043)
Lancaster Sound[a] (Taylor *et al.* 2008b)	0.633 (0.123)	0.790 (0.073)	0.790 (0.073)	0.892 (0.030)	0.653 (0.085)	0.749 (0.105)	0.879 (0.050)	0.879 (0.050)	0.936 (0.019)	0.758 (0.054)
M'Clintock Channel (Taylor *et al.* 2006a)	0.620 (0.15)	0.900 (0.04)	0.900 (0.04)	0.880 (0.04)	0.880 (0.04)	0.620 (0.15)	0.900 (0.04)	0.900 (0.04)	0.900 (0.04)	0.900 (0.04)
Northern Beaufort Sea (Stirling *et al.* 2007)[b]	0.487 (0.173)	0.248 (0.124)	0.826 (0.073)	0.818 (0.071)	0.581 (0.104)	0.605 (0.170)	0.348 (0.147)	0.895 (0.046)	0.89 (0.044)	0.713 (0.079)
Norwegian Bay[a] (Taylor *et al.* 2008b)	0.633 (0.123)	0.790 (0.073)	0.790 (0.073)	0.892 (0.030)	0.653 (0.085)	0.749 (0.105)	0.879 (0.050)	0.879 (0.050)	0.936 (0.019)	0.758 (0.054)
Southern Beaufort Sea (Regehr *et al.* 2006)	0.430 (0.110)	0.920 (0.040)	0.920 (0.040)	0.920 (0.040)	0.920 (0.040)	0.430 (0.110)	0.920 (0.040)	0.920 (0.040)	0.920 (0.040)	0.920 (0.040)
Southern Hudson Bay (Obbard *et al.* 2007)[c]	0.492 (0.143)	0.485 (0.143)	0.812 (0.076)	0.811 (0.076)	0.293 (0.143)	0.645 (0.135)	0.640 (0.136)	0.893 (0.052)	0.892 (0.052)	0.444 (0.148)
Viscount Melville (Taylor *et al.* 2002)	0.448 (0.216)	0.774 (0.081)	0.774 (0.081)	0.774 (0.081)	0.774 (0.081)	0.693 (0.183)	0.905 (0.026)	0.905 (0.026)	0.905 (0.026)	0.905 (0.026)
Western Hudson Bay[d,e] (Regehr *et al.* 2007a)	0.620 (0.020)	0.620 (0.020)	0.810 (0.015)	0.900 (0.005)	0.750 (0.020)	0.700 (0.020)	0.700 (0.020)	0.860 (0.015)	0.930 (0.005)	0.810 (0.015)
			0.720 (0.020		0.650 (0.031)			0.780 (0.020)		0.720 (0.031)

[a] Survival rates pooled for Lancaster Sound and Norwegian Bay (see Taylor *et al.* 2008b and Sections 7.6 and 7.5).

[b] 2003–2005 means. Estimated SE is the difference between the mean estimate and mean upper confidence limit, divided by 1.96. Rates are too variable and inconsistent with known biology of polar bears (yearling rates) to conduct population simulations (see text section 7.3).

[c] 2004 means. Estimated SE is the confidence interval, divided by 3.92.

[d] Survival rates listed in the age 5-20 category apply to age 5-19; rates listed in the >20 category apply to the ages ≥20.

[e] Regehr *et al.* (2007a) present total apparent survival rates for Western Hudson Bay polar bears as 95% CI. Estimated SE is the difference between the estimate and upper CL, divided by 1.96. Survival rates presented for 2-4 and 20+ adults are those that are not reduced from capture events around Churchill (see Regehr *et al.* [2007a]). Survival rates for 2-4 and ≥20 age categories in Western Hudson Bay may be as low as 0.72 and 0.65 for males and 0.78 and 0.72 for females, respectively. The true survival rates for subadult and senescent bears in Western Hudson Bay likely lie somewhere between the rates in the table and those stated in the previous sentence (E. Regehr, personal communication, USGS, Alaska Science Center, Anchorage, AK).

Table 5. Mean (SE in parentheses) of natural (i.e., unharvested) annual survival rates for age and sex classes of subpopulations of Canadian polar bears. No other subpopulations have reported natural survival rates or rates that can be computed.

Subpopulation (primary data source)	**Males**					**Females**				
	Natural Survival					**Natural Survival**				
	0	**1**	**2–4**	**5–20**	**>20**	**0**	**1**	**2–4**	**5–20**	**>20**
Baffin Bay (Taylor *et al.* 2005)	0.570 (0.094)	0.938 (0.045)	0.938 (0.045)	0.947 (0.022)	0.887 (0.060)	0.620 (0.095)	0.938 (0.042)	0.938 (0.042)	0.953 (0.020)	0.919 (0.050)
Gulf of Boothia (Taylor *et al.* 2008c)	0.817 (0.201)	0.907 (0.084)	0.907 (0.084)	0.959 (0.039)	0.959 (0.039)	0.817 (0.201)	0.907 (0.084)	0.907 (0.084)	0.959 (0.039)	0.959 (0.039)
Kane Basin (Taylor *et al.* 2008a)	0.345 (0.200)	0.663 (0.197)	0.663 (0.197)	0.997 (0.026)	0.997 (0.026)	0.410 (0.200)	0.756 (0.159)	0.756 (0.159)	0.997 (0.026)	0.997 (0.026)
Lancaster Sound[a] (Taylor *et al.* 2008b)	0.634 (0.123)	0.838 (0.075)	0.838 (0.075)	0.974 (0.030)	0.715 (0.095)	0.750 (0.104)	0.898 (0.005)	0.898 (0.005)	0.946 (0.018)	0.771 (0.054)
M'Clintock Channel (Taylor *et al.* 2006a)	0.619 (0.151)	0.983 (0.034)	0.983 (0.034)	0.977 (0.033)	0.977 (0.033)	0.619 (0.151)	0.983 (0.034)	0.983 (0.034)	0.921 (0.046)	0.921 (0.046)
Northern Beaufort Sea (Stirling *et al.* 2007)[b]	0.489 (0.173)	0.928 (0.080)	0.906 (0.073)	0.940 (0.071)	0.859 (0.104)	0.607 (0.170)	0.931 (0.080)	0.956 (0.046)	0.929 (0.044)	0.730 (0.079)
Norwegian Bay[a] (Taylor *et al.* 2008b)	0.634 (0.123)	0.838 (0.075)	0.838 (0.075)	0.974 (0.030)	0.715 (0.095)	0.750 (0.104)	0.898 (0.005)	0.898 (0.005)	0.946 (0.018)	0.771 (0.054)
Southern Beaufort Sea[c] (Regehr *et al.* 2006, 2007b)	0.430 (0.11)	0.930 (0.040)	0.930 (0.040)	0.930 (0.040)	0.930 (0.040)	0.430 (0.11)	0.930 (0.040)	0.930 (0.040)	0.930 (0.040)	0.930 (0.040)
Southern Hudson Bay[d] (Obbard *et al.* 2007)	0.492 (0.143)	0.517 (0.143)	0.929 (0.076)	0.892 (0.076)	0.556 (0.143)	0.645 (0.135)	0.645 (0.136)	0.973 (0.052)	0.951 (0.052)	0.523 (0.148)
Viscount Melville (Taylor *et al.* 2002)	0.448 (0.216)	0.924 (0.109)	0.924 (0.109)	0.924 (0.109)	0.924 (0.109)	0.693 (0.183)	0.957 (0.028)	0.957 (0.028)	0.957 (0.028)	0.957 (0.028)
Western Hudson Bay[e] (Regehr *et al.* 2007a)	0.710	0.710	0.940 0.780	0.940	0.820 0.680	0.730	0.920	0.920 0.820	0.930	0.820 0.720

[a] Survival estimates pooled for Lancaster Sound and Norwegian Bay (see Sections 7.6 and 7.5).

[b] Natural survival estimates for the Northern Beaufort Sea were estimated by adding harvest mortality to total survival. The yearling survival rate from the adjacent Southern Beaufort Sea was used (substituted) because the Northern Beaufort estimate of total survival for yearlings (Stirling *et al* 2007) has been acknowledged as an underestimation. The SE for Southern Beaufort yearling survival was doubled to reflect the increased uncertainty of a meta-analysis approach.

[c] Based on survival rates provided by E. Regehr (USGS, Alaska Science Center, Anchorage, AK).

[d] Obtained from the last year (2004) survival estimates in Obbard *et al.* (2007) and using all captures pooled to 2000 to estimate the standing age distribution and relative proportions of sex/age groups identified in Obbard *et al.*'s analysis. These proportions were multiplied by the population estimate (N = 681) to get the current number of individuals in each strata. Using the harvest sex and age distribution, the proportions of the known kill (36.2 bears from 2002–2007) were apportioned according to the same sex/age strata identified by the Obbard *et al.* survival estimates. The contribution to total mortality provided by harvest mortality was then obtained by dividing the number of individuals in the appropriate harvest strata by the number of individuals in the appropriate population strata. Natural survival was calculated by then adding harvest mortality to total survival by strata (i.e., raising total survival rates by the apportioned known mortality rates).

[e] Natural survival rates provided in Regehr *et al.* (2007a) include two estimates for the 2-4 and 20+ age categories. The top estimate is for the mark-recapture model that excludes a capture effect on mortality of handling bears in Churchill; in the bottom estimate the rates are reduced to reflect heterogeneity in the data associated with captures around Churchill by the Manitoba Department of Conservation. Regehr *et al.* (2007a) present no error estimates with these rates; for simulations (Table 6) the errors associated with total survival rates were used.

5.2 Predation

Polar bears have no natural predators. Intraspecific predation is, however, a potential limiting factor of population growth. The killing of cubs to bring females into estrus, or killing of cubs and adults for food, is not uncommon in Ursidae, including polar bears (Taylor *et al.* 1985; Derocher and Taylor 1994; Taylor 1994; Derocher and Wiig 1999; Dyck and Daley 2002). Intraspecific conflicts related to nutritional stress are expected to be higher as density (relative to the carrying capacity of the environment) increases. Hence, if climate change acts to reduce carrying capacity, we might expect increases in rates of intraspecific conflict where declines in population size lag behind changes in carrying capacity (e.g., Southern Beaufort Sea [Amstrup *et al.* 2006]). The potential for intraspecific predation to limit polar bears is discussed in more detail in Section 6.3.

5.3 Physiology

The most notable aspect of polar bear physiology, in the context of assigning status to the species, relates to the ability of polar bears to fast for long periods of time when forced on land during the ice-free season, without access to seals (50–60% of bears in Canada). While on land little food is available, and bears must rely on stored energy reserves until the sea ice forms again in late autumn (Ramsay and Hobson 1991; Derocher *et al.* 1993; Atkinson and Ramsay 1995). Pregnant females must also wait until young are born and old enough to be moved from the den before ending their fast; in doing so pregnant females may not eat for up to 8 months, while having to meet the energetic demands of gestation and lactation (Atkinson and Ramsay 1995). Adult polar bears lose approximately 1 kg of body mass per day during fasts (Derocher and Stirling 1995a; Polischuk *et al.* 2002), and pregnant females may lose as much as 43% of their body mass (Atkinson and Ramsay 1995). Because offspring body mass is closely tied to the amount of body fat carried by females (Atkinson and Ramsay 1995), reproductive success likely depends on how heavy females are when they begin, or more importantly end, periods of fasting.

As an apex predator in the arctic marine ecosystem, polar bears may be exposed to a number of environmental pollutants and contaminants that have the potential to affect survival and reproduction (Amstrup 2003). Important environmental contaminants and their potential limiting effects on polar bears are discussed in Section 6.3.

5.4 Home Ranges, Movements, and Dispersal

Polar bears travel over exceedingly large areas relative to other terrestrial mammals (Ferguson *et al.* 1999), and the only practical means by which to track their movements is via remote satellite telemetry (see Messier *et al.* 2001). Radios are generally fitted using collars only on adult females given practical difficulties in securely attaching transmitters to males (necks of males are often of wider circumference than their heads); hence, movement patterns of male polar bears are not well known. Female polar bears possess large annual home ranges, varying from 940 km^2 to 540,700 km^2 ($\bar{x}$ = 125,500 km^2, SD = 113,795, n = 93; Ferguson *et al.* 1999). Home ranges of polar bears vary with several factors, including local presence of attractants such as polynyas (Ferguson *et al.* 1999; Messier *et al.* 2001). The ratio of land to sea within a given home range and seasonal variation in ice cover have been shown to explain up to 66% of the variation in home range size (Ferguson *et al.* 1999). Bears using land during the ice-free season have larger home ranges than those with year-round access to ice, as do bears that possess home ranges with greater seasonal variation in type of ice cover (Ferguson *et al.* 1999).

Observations of movement patterns within home ranges reinforce the importance of sea ice to the ecology of polar bears. As expected from the size of home ranges, rates of movement are very high when compared to other terrestrial mammals, with most published, mean estimates of travel speeds on sea ice falling within the range of 0.5–2.1 km/h (Larsen *et al.* 1983; Durner and Amstrup 1995; Born *et al.* 1997; Amstrup *et al.* 2000; Ferguson *et al.* 2001). The highest activity is from May through June and July, depending on conditions of sea ice and coinciding with availability of newborn seal pups (Pasitschniak-Arts and Messier 1999; Amstrup 2003). Mauritzen *et al.* (2003) showed that movement rates of polar bears increased with decreasing thickness of sea ice. In the High Arctic, activity is lowest during winter, perhaps due to inclement weather, limited accessibility to seals, and energy conservation during the coldest months (Messier *et al.* 1992, 1994).

Movements of pregnant females cease after they enter maternity dens in late autumn (Section 5.1), but non-pregnant females and males will also use snow shelters for 0.5–4 months of the winter (Harington 1968) and fast in a manner that is physiologically similar to torpor during periods of food shortages (Watts and Hansen 1987). However, use of shelter dens varies with conditions of sea ice and latitude and is more common in the High Arctic (Ferguson *et al.* 2000b). In the southern Arctic, where sea ice melts, bears may be forced to spend up to several months on land while waiting for freeze-up. This phenomenon is most marked at the southern range of the polar bear in Canada, especially Hudson Bay and James Bay (Stirling *et al.* 1977; Derocher and Stirling 1990), eastern Baffin Island (Stirling *et al.* 1980; Ferguson *et al.* 1997; Taylor *et al.* 2005), and Davis Strait (M.K. Taylor, Department of Environment, Government of Nunavut, pers. obs.). Once forced on shore for summer, movements are considerably less than on sea ice and bears spend most of their time resting or, if female and pregnant, investigating areas of potential den sites (Ferguson *et al.* 1997, 1998; Lunn *et al.* 2004).

Dispersal in polar bears is poorly understood largely because subadult bears have rarely been tracked using radio-collars. Subadults, though marked when captured, are not usually collared as these bears can quickly outgrow fitted collars. Dispersal events have, however, been recorded using genetic analyses (Crompton 2004; Saunders 2005). Results from bears in the Gulf of Boothia and M'Clintock Channel (Saunders 2005), and Western Hudson Bay, Southern Hudson Bay, Foxe Basin, and Davis Strait (Crompton 2004) suggest that dispersing bears can and do traverse identified subpopulation boundaries. Dispersal across subpopulation boundaries—initially identified based on movements of marked and radio-collared adults (Taylor and Lee 1995; Bethke *et al.* 1996)—may in part explain the lack of sharp genetic differences among subpopulations (Tables 1 and 2).

5.5 Interspecific Interactions

Polar bears are obligate predators of ice-dependent seals, especially the ringed seal. Coevolution between ringed seals and polar bears and the potential for distributional changes in the occurrence of ringed seals (and other ice-dependent phocids) on polar bear distribution are discussed in Sections 3, 4, and 6.

5.6 Behavioural Adaptations

In addition to being physiologically adapted to environmental stochasticity and surviving long periods without food, polar bears exhibit behavioural adaptations that allow them to survive in extreme or variable environments. Participants of recent ATK studies in Gjoa Haven, Cambridge Bay and Taloyoak (Atatahak and Banci 2001; Keith *et al.* 2005) communicated that polar bears readily adapt their movements to environmental conditions and availability of prey species, but can be sensitive to human activity. However, polar bears are known to use non-natural sources of food (e.g., garbage) and may habituate to the presence of humans, even in the presence of disruptive activities (e.g., hazing) if food rewards can still be obtained. The curiosity of polar bears makes them particularly vulnerable to human-caused mortality in defence of life or property. Polar bears are also attracted to and may consume foreign substances (e.g., petroleum products or ethylene glycol [antifreeze]) that can be harmful or cause death (Stirling 1988b; Amstrup *et al.* 1989; Derocher and Stirling 1991). Inuit observations of polar bears eating plastic bags and engine oil apparently increased through the 1990s (McDonald *et al.* 1997), and Inuit observers of polar bears in the Baffin Bay area report an expansion in the types of foods eaten by bears in recent years (Dowsley 2005), including eggs of sea birds and Inuit meat caches. As described in Section 4.1, the diet of polar bears can extend to several species of mammals and birds, Inuit meat caches; and vegetation including berries; however, polar bears are best characterized as an obligate predator of seals using sea ice as a hunting platform.

6. LIMITING FACTORS AND THREATS

The main, proximate limiting factors (i.e., immediate factors that directly cause mortality or reduce reproduction) affecting polar bear distribution and abundance are starvation (access to and abundance of ice-dependent seals), human-caused mortality (almost exclusively from hunting), and intraspecific predation. Other potential proximate factors include contamination, especially that associated with offshore development of hydrocarbon reserves and increased sea traffic in the Arctic, and the accumulation of environmental contaminants (mainly organochlorines) in tissues of polar bears. Climate change will likely influence all of the proximate limiting factors to polar bears listed above and may therefore become the ultimate limiting factor for the species. Review papers (e.g., Stirling and Derocher 1993; Barber and Iacozza 2004; Derocher *et al.* 2004; Stirling and Parkinson 2006), documents of ATK (e.g., Dowsley 2005), and observational reports (e.g., Amstrup *et al.* 2006; Monnett and Gleason 2006) offer insight into the possible impacts of past and continued climate warming on polar bears. Empirical studies of correlations between variables of climate change and body condition (Stirling *et al.* 1999; Obbard *et al.* 2006), and, recently, demographic rates (Obbard *et al.* 2007; Regehr *et al.* 2006, 2007a,b; Stirling *et al.* 2007) are more useful for quantitative predictions of how climate warming might underlie proximate limiting factors and threats faced by bears (see also Section 4.2). Here we treat climate change as an integral part of any discussion of the limiting factors to polar bears.

6.1 Food Availability

Recently, researchers of the Canadian Wildlife Service and USGS Alaska Science Center established a relationship between earlier break-up of sea ice in Western Hudson Bay and decreased survival of non-prime adult age classes of polar bears (Regehr *et al.* 2007a; see also Section 4.2), providing the first quantitative evidence for effects of climate-related stressors on polar bear population dynamics. Coupling reduced survival for most age and sex classes in Western Hudson Bay with observations that body size of females coming off the sea ice has declined in association with earlier break-up in spring (Stirling *et al.* 1999), decline in the polar bear subpopulation of Western Hudson Bay (Section 7.10) is best explained by reduced access to food. Similar conclusions have been reached for polar bears of the Southern Hudson Bay (Regehr *et al.* 2007b; Rode *et al.* 2007).

In Western Hudson Bay, there is some evidence that ringed seal reproduction has been reduced by climate warming (Ferguson *et al.* 2005; Stirling 2005); hence, polar bears may be responding to reductions in numbers of seals. It is possible that, at least in the context of maintained levels of human-caused mortality: 1) density of polar bears will track seal numbers; or 2) if earlier dates of break-up of sea ice do not allow enough time for bears to accumulate fat reserves required to endure fasting, declines in abundance may occur before or in the absence of observable declines in seal numbers. It is also important to note that not all segments of a polar bear population are expected to immediately decline in response to a reduction in food carrying capacity. In Western Hudson Bay, Regehr *et al.* (2007a) suggested that prime-aged adults were most likely “in better body condition than other polar bears (E. Richardson, CWS, unpublished data), able to divert resources from reproduction to survival in times of nutritional stress, …better at catching seals, and more able to take seal kills away from subordinate polar bears." This may explain why no association between survival of prime-aged adult females and males and earlier break-up of sea ice was detected by Regehr *et al.* (2007a). For all other age classes, a statistical relationship between earlier break-up and decreased survival was shown.

Derocher *et al.* (2004) provide a synopsis of possible scenarios of changes in food availability to polar bears in the context of climate change, including the potential for climate warming to benefit some subpopulations, at least over the shorter term. This might apply to polar bears at the extreme northern edge of the species' range (e.g., Viscount Melville Sound, western Lancaster Sound, Norwegian Bay, Kane Basin, and the Arctic Basin), where low primary productivity and multi-year sea ice limits densities of and access to ringed seals (Kingsley *et al.* 1985). Even within areas of relatively close proximity, the impact of climate change might vary substantially. For example, during the period of decreased abundance of polar bears in Western Hudson Bay attributed to impacts of climate change (above, Sections 4.2 and 7.10), there was no observable decline in numbers of bears in Southern Hudson Bay (Section 7.11), although concordant declines in body condition were evident (Obbard *et al.* 2007). Following a new analysis of mark-recapture data first presented in Kolenosky *et al.* (1992), researchers of the Government of Ontario reported that abundance of polar bears in Southern Hudson Bay was 641 bears (95% CI 401–881) in 1986 and 681 (95% CI 401–961) in 2005 (Obbard *et al.* 2007).

Although it remains uncertain as to how every subpopulation will respond to climate warming, it follows that there is a minimum period of at least annual sea ice (likely modified by factors such as prey availablity) conducive to the presence of polar bears. Only rarely have polar bears been observed to kill seals while swimming in open water (Furnell and Oolooyuk 1980), and killing of seals and walrus when hauled out on land will likely never replace the advantage of killing seals from sea ice (Derocher *et al.* 2004). Polar bears do not live where there is not at least annual sea ice, but many species of seals do. If climate warming were to prevent the formation of winter sea ice, or to substantially increase the duration of the open-water season in areas with seasonal ice currently used by polar bears, there is no hope that their numbers will remain viable in the affected subpopulation.

6.2 Human-Caused Mortality

The most important proximate, limiting factor to the polar bear is presently human-caused mortality. In Canada this largely occurs through regulated hunting. For most age and sex groups, much of the annual mortality can be attributed to the known human-caused mortality (Section 5.1; Table 6). Over-harvest is of major concern for some demographic units, particularly where there is outdated information on abundance or a lack of enforceable quotas (Section 9.3). In the past, some Canadian polar bear subpopulations have been over-hunted (because of overestimation of population abundance and therefore quotas), with unfortunate examples coming from M'Clintock Channel (Taylor *et al.* 2006a) and the Viscount Melville Sound (Taylor *et al.* 2002).

Today, substantially reduced mean rates of annual kill (34.0 bears [1979–1999] reduced to 1.8 bears [2002–2007] for M'Clintock Channel; 19.6 bears [1985–1990] reduced to 4.8 bears [2002–2007] for Viscount Melville Sound) are projected by simulations to have reversed trends in these subpopulations (Taylor *et al.* 2002, 2006a), although numbers remain severely reduced (Table 6, Sections 7.4 and 7.7). The same method has been used to project ongoing and severe instances of over harvest in polar bears of Baffin Bay and Kane Basin (Sections 7.12 and 7.13).

The most important problems with over-hunting are for the subpopulations of Kane Basin and Baffin Bay, and Western Hudson Bay in the context of lowered natural survival rates and climate change (Section 7.10). The governments of both Nunavut and Greenland have substantially increased their kill in Baffin Bay and Kane Basin in recent years (the 2006–2007 harvest of polar bears in Baffin Bay was 99 for Nunavut [increased from a quota of 54 in 2004] and 75 for Greenland; PBTC 2008). However, the Baffin Bay subpopulation was projected by Taylor *et al.* (2005) to be able to sustain an annual harvest of approximately 90 bears in 1997. Although Greenland has, as of January, 2006, instituted its first quota for polar bear hunting, which should reduce the kill of polar bears in Kane Basin and Baffin Bay (West Greenland harvest is not to exceed 100 bears/year; PBTC 2006), reversal of what we expect to be severe population decline (Table 6) is not likely to have occurred. The current combined Nunavut/Greenland regulated harvest of polar bears in Kane Basin and Baffin Bay continues to be excessive (Table 6, Sections 7.12 and 7.13).

Table 6. Status of subpopulations of polar bears within or shared by Canada. See footnotes next page and Sections 7.1–7.14 for details.

Subpopulation (primary data source)	Previous Abundance Estimate		Current Abundance Estimate		Human-caused Mortality		Results of Population Simulations[a]			2008 STATUS
	N_1 (year of estimate)	95% CI of N_1	N_2 (year of estimate)	95% CI of N_2	Permitted harvest (bears/year)	2002–2007 mean kill (bears/year)	λ ± 1 SE[b] at current kill	PVA[c]	λ ± 1 SE under harvest moratorium[d]	Based on weight of evidence[e]
Baffin Bay (Taylor *et al.* 2005, IUCN/SSC Specialist Group 2006)	2074 (1998)	1544–2604	1546 (2004)	690–2402	105 + Greenland	232.4	0.861 ± 0.075	0.998	1.054 ± 0.027	Declining
Davis Strait (Peacock *et al.* 2006, PBTC 2007)	900 (1980)	n/a	2251 (2006)	n/a	52 + Greenland, Quebec	60.0	n/a	n/a	n/a	Unknown[f]
Foxe Basin (Taylor *et al.* 2006b, IUCN/SSC Specialist Group 2006)	2119 (1996)	1421–2817	2300[g] (2004)	1780–2820[h]	106 + Quebec	98.6	n/a	n/a	n/a	Unknown
Gulf of Boothia (Taylor *et al.* 2008c)	n/a	n/a	1528 (2000)	953–2093	74	56.4	1.025 ± 0.032	0.067	1.065 ± 0.019	Increasing
Kane Basin (Taylor *et al.* 2008a)	n/a	n/a	164 (1998)	94–234	5 + Greenland	12.8	0.935 ± 0.027	0.999	1.010 ± 0.010	Declining
Lancaster Sound (Taylor *et al.* 2008b)	1031 (1979)	795–1267	2541 (1998)	1759–3323	85	82.4	1.001 ± 0.014	0.260	1.023 ± 0.012	Stable
M'Clintock Channel (Taylor *et al.* 2006a)	700 (1978)	n/a	284 (2000)	166–402	3	1.8	1.022 ± 0.015	<0.001	1.031 ± 0.038	Increasing
Northern Beaufort Sea (Stirling *et al.* 2007)	867 (1986)	726–1008	1200 (2006)	825–1135	65	34.4	0.994 ± 0.023[j]	0.419[j]	1.031 ± 0.021[j]	Stable[j]
Norwegian Bay (Taylor *et al.* 2008c)	n/a	n/a	190 (1998)	102–278	4	3.0	0.997 ± 0.026	0.439	1.006 ± 0.016	Stable?
Southern Beaufort Sea (Regehr *et al.* 2006, 2007b)	1800 (1983)	1300–2500[h]	1526 (2006)	1211–1841	81	53.4	0.938 ± 0.030	0.945	0.980 ± 0.029	Declining
Southern Hudson Bay (Obbard *et al.* 2007a,b)	641 (1986)	401–881	681[k] (2005)	401–961	25 + Ontario, Quebec	36.2	0.969 ± 0.055[l]	0.670[l]	1.028 ± 0.076[l]	Stable[l]
Viscount Melville Sound (Taylor *et al.* 2002)	161 (1993)	121–201	215 (1996)	99– 331	7	4.8	1.037 ± 0.033	0.072	1.059 ± 0.063	Increasing
W. Hudson Bay[m] (Regehr *et al.* 2007a)	1194 (1987)	1020–1368	935 (2005)	794–1076	46 + Manitoba	46.8	0.940 ± 0.013 0.903 ± 0.014	0.999 0.999	0.999 ± 0.011 0.964 ± 0.011	Declining
TOTAL	Current estimate 15000 (11000–19000)[n]				>643	734.6[o]	n/a	n/a	n/a	Declining[p]

Footnotes for Table 6.

[a] Simulation results are population projections. Models for subpopulations were developed from information contained in Tables 3–5 using the simulation model RISKMAN. Models were only conducted for subpopulations where data were of sufficient quality to project the population with reasonable confidence.

[b] Current trajectory of a subpopulation based on survival rates and current kill (2002–2007) as estimated by the annual (finite) rate of population increase ($\lambda \pm 1$ SE) in the first 5 years of simulation. Values > 1 indicate a growing population; values < 1.0 indicate a declining population. Rates are current to the most recent estimation of survival, reproduction, and abundance (N_2).

[c] Results of population viability analysis (PVA), which are presented as the proportion of simulation runs using the RISKMAN model resulting in >30% decline after 36 years of simulation (i.e., 3 generations of polar bears as generation length is defined by COSEWIC [12 years for polar bears, see Section 5.1]), using 2,500 simulations to develop distributions. The likelihood of population decline converges on a single percentage without error after running a large number of simulations (>1,000 simulations), and so no error estimate is applicable to likelihood of decline. See Section 7.1 for details on how simulations were conducted.

[d] The annual (finite) rate of population increase ($\lambda \pm 1$ SE) if kill were held at zero (i.e., harvest moratorium enacted). These simulations are useful because they can identify subpopulations where decline is likely inevitable at zero harvest.

[e] Current status identifies the likely trend for each subpopulation as of 2008, based on the weight of evidence in favour of declining, stable, or increasing status obtained from: 1) identified trend from N_1 to N_2; 2) population simulations identifying finite rate of increase and results of PVA (taking into consideration the current kill); and 3) conclusions reached by authors of the primary source listed for each subpopulation.

[f] Trend in Davis Strait is pending an ongoing analysis of three years of mark-recapture data (data collection is complete). It is clear, however, that abundance is much higher than previously thought (Peacock *et al.* 2006).

[g] Derived from ATK and the expectation that the population increased under past rates of harvest.

[h] Estimated minimum and maximum range only.

[i] Underestimate because the 1979 study area (Schweinsburg *et al.* 1982) differs substantially from that used to determine the 1998 estimate (Taylor *et al.* 2008b). The study area of Taylor *et al.* (2008b) is much larger and extends further to the west, north, and south of Lancaster Sound, although Taylor *et al.* (2008b) exclude portions of northern Baffin Bay included in the assessment of Schweinsburg *et al.* (1982).

[j] Stirling *et al.* (2007) conclude that the population has been stable in numbers, and that earlier estimates of abundance were biased low. Survival rates of yearlings from Stirling et al (2007) are acknowledged to be under-estimated, so a meta-analysis approach was used for simulations. Yearling survival rate estimates were incorporated from the adjacent Southern Beaufort Sea (Regehr *et al.* 2006, 2007b; Table 4). Errors in survival rate estimates may be due to unmodelled heterogeneity in the data.

[k] Abundance estimates for Southern Hudson Bay in Obbard *et al.* (2007) are suggested by Obbard *et al.* to underestimate the true abundance by 70-110 bears.

[l] Highly variable and apparently unrealistic survival rate estimates preclude a confident simulation. Trajectories based on population simulations may be biased low if the survival rates presented in Obbard *et al.* (2007) have been under-estimated. Using the same data, Obbard *et al.* (2007) conclude that the population has been constant in number since the mid-1980s, but may decline in the future because of observed reductions in body condition likely associated with climate change.

[m] Population simulations for Western Hudson Bay conducted using the high (top row) and low (bottom row) survival rates for ages 2–4 and ≥20 as presented in Table 5 and Regehr *et al.* (2007a).

[n] Sum total of most recent population means. The range of minimum and maximum is approximate and based on confidence intervals.

[o] Total kill includes U.S. and Greenland harvesting. Total human-caused mortality from 2002–2007 for all subpopulations within and shared by Canada was estimated to average 4.9% per year. All kill data from PBTC (2008).

[p] Data on survival, harvest, and reproduction suggest that 4 of 13 subpopulations (Western Hudson Bay, Southern Beaufort Sea, Baffin Bay, and Kane Basin), representing approximately 27.8% of the total population of 15,500 polar bears shared by Canada and its immediate neighbours (Greenland and the United States), are likely declining at a high rate at the present time. Four subpopulations (Northern Beaufort Sea, Southern Hudson Bay, Norwegian Bay, and Lancaster Sound) are most likely to be stable (growth rates [λ] close to 1.0 [either slowly increasing or slowly declining]). Three subpopulations (Viscount Melville Sound, M'Clintock Channel, and Gulf of Boothia) are most likely to be increasing (13.5% of the total population). Trend cannot be reported due to pending analysis for Davis Strait and lack of data for Foxe Basin (combining to a rough estimate of 29.4% of the total population). Collectively, these data suggest that the overall trend for the polar bear population in Canada is currently in slow decline.

How human-caused mortality interacts with climate warming and impending changes to abundances of or access to seals is of considerable importance to the conservation of polar bears. Perhaps the most important impact of climate change on the manner in which polar bears are killed in Canada will come in the form of an anticipated increase in bear-human conflicts (Derocher *et al.* 2004; Stirling and Parkinson 2006). As alluded to in Section 6, reductions in food availabilty may result in increases in nutrionally stressed bears spending longer periods of time onshore, where humans live. Increases in problem bear activity in areas most affected by climate warming have been reported in recent years, including the Southern Beaufort Sea (Schliebe *et al.* 2006) and Western Hudson Bay (McDonald *et al.* 1997; Stirling *et al.* 1999; Stirling and Parkinson 2006), and a positive interaction between climate warming and human-caused mortality may pose a serious problem. Stirling and Parkinson (2006) clearly show that for Western Hudson Bay, the earlier the ice breaks up the more problem bears there are in a year, and vice versa (see Figure 4 of Stirling and Parkinson [2006]). The perception of increased numbers of problem bears has also been voiced repeatedly by Inuit participants at meetings of the Federal/Provincial/Territorial Polar Bear Committee, and through collection of ATK (see Section 7). In some cases, higher numbers of problem bears may indicate higher abundance, an argument given for increasing hunting quotas in almost every subpopulation in Nunavut in 2005 (IUCN/SSC Polar Bear Specialist Group 2006); however, the best available scientific data support the notion that perceived higher numbers of bears is the result of bears coming off the ice in poorer condition and becoming problem animals in greater numbers due to earlier break-up of sea ice (see Stirling and Parkinson 2006).

Of particular importance, simulation models (Section 7.1; Table 6) suggest that for the subpopulations of Western Hudson Bay and Southern Beaufort Sea, both impacted by effects of climate change, even with a harvest moratorium declines would be inevitable. That is, the populations are no longer viable at their present abundances. Currently, this is not likely to be the case for most subpopulations of polar bears in Canada (Table 6), but vital statistics may be changed in the future by changes in ice availability.

6.3 Other Limiting Factors

As noted in Section 5.2, polar bears, like all ursids, kill and eat members of their own species, and intraspecific predation is a potential regulating factor (i.e., density-dependent limiting factor) for polar, brown, and black bears (Taylor 1994). As such, intraspecific predation would be expected to occur at a higher frequency when polar bear subpopulations are at relatively high density. It is unlikely that polar bear subpopulations as they exist today are approaching abundances that, at least in the past, would have been associated with population carrying capacity. However, intraspecific predation continues to be observed and recent, potential spikes in instances of intraspecific predation (e.g., Amstrup *et al.* 2006) suggest that, in areas most affected by climate change, carrying capacity of the environment has been lowered for polar bears. This hypothesis presents a plausible explanation for the purported link between climate warming and increased conflicts within the polar bear population, and may also explain recent instances of increased conflicts between humans and polar bears (Section 6).

Since the mid-1960s, exploration for energy and mineral reserves has led to an increased amount of industrial activity in the Arctic. Concerns about disturbance of bears at denning areas due to noise or construction have been voiced in recent interviews of ATK (Atatahak and Banci 2001; Keith *et al.* 2005), and new activity in the Arctic has the potential to increase killing of bears in defence of life or property. However, the primary threat to polar bears from industrial development may come from the potential for environmental contamination, especially large-scale oil spills. Oil is extremely toxic and potentially lethal to bears in even small amounts (Øritsland *et al.* 1981; Stirling 1990; Derocher and Stirling 1991). Although recent oil-spill simulations (Durner *et al.* 2001) suggest that relatively few bears in Canada (Southern Beaufort Sea) would encounter oil if a major spill occurred from existing operations, as climate change increases access to the polar basin we might anticipate increased risks to bears with development in the Canadian Arctic Archipelago. Extensive discovered and recoverable oil and gas reserves exist in Nunavut, including the 3.3×10^6 barrel (oil) and 17.4×10^8 ft^3 (gas) reserves of the Sverdrup sedimentary basin (Drummond 2006), which overlap the subpopulations of Norwegian Bay, Lancaster Sound, Viscount Melville Sound, and Northern Beaufort Sea. Reserves of an additional 2.3×10^8 ft^3 of natural gas occur in Baffin Bay (Drummond 2006). Continued development of the 1.0×10^7 barrel (oil) and 9.7×10^8 ft^3 (natural gas) petroleum reserves of the Beaufort Sea/Mackenzie Delta in the Northwest Territories (Drummond 2006) may put additional pressure on the Southern Beaufort Sea subpopulation of polar bears.

In recent years, significant levels of various contaminants (organochlorines and other persistent organic pollutants) have been documented in polar bear tissues or tissues of their prey, particularly adipose tissue (e.g., Born *et al.* 1991; Norstrom *et al.* 1988, 1998; Norstrom and Muir 1994; Bernhoft *et al.* 1996; Letcher *et al.* 1995; Henriksen *et al.* 2001; Kucklick *et al.* 2002; Oskam *et al.* 2004; Wolkers *et al.* 2004; Smithwick *et al.* 2005; Muir *et al.* 2006). Effects of various compounds in the tissues of polar bears or of the seals they feed on remains largely unknown. Although contaminant levels in some subpopulations correlate with impaired endocrine function (Skaare *et al.* 2001; Oskam *et al.* 2004), immune function (e.g., Bernhoft *et al.* 2000; Skaare *et al.* 2002; Lie *et al.* 2004, 2005), and potentially bone mineral composition (Sonne *et al.* 2004), there has been little demonstration of demographic effects from contaminants on polar bears (Amstrup 2003).

Inuit interviewed for ATK have recently expressed concerns that studies for scientific research, whereby bears are immobilized using drugs and helicopters and snowmobiles are used to capture bears, may cause displacement of bears or result in long-term, adverse physiological effects (McDonald *et al.* 1997; Atatahak and Banci 2001; Dowsley and Taylor 2006a; Dowsley 2005). However, scientific research is clearly not a limiting factor on polar bears. Messier (2000), after analyzing 3,237 research handlings of polar bears for the period 1989–1997, concluded that long-term effects on polar bears of tagging and radio-collaring are largely negligible from the perspective of population dynamics. Nonetheless, polar bears are sometimes killed by accident during the course of scientific research. Messier (2000) reported that mortalities occurred at an average rate of 1 per 1,000 bears handled for management and population studies. Risk of mortality was higher for more complex handling protocols associated with studies of physiology (28 bears per 1,000 bears handled).

In all likelihood and within our lifetimes, due to climate warming, the Northwest Passage (recently renamed the Canadian Internal Waters by the Government of Canada) will remain open for increasing periods of time, making it attractive as a major shipping route. Routes from Europe to the Far East are reduced by as much as 4,000 km by travel through the waterway, as compared to the route through the Panama Canal. Polar bears in the vicinity of this new shipping route may be exposed to traffic and levels of pollution that no subpopulation of polar bear has yet experienced. How they will respond to these cumulative effects is unknown.

7. POPULATION SIZE AND TRENDS

This section updates summaries presented in the previous COSEWIC report on the status of polar bears (COSEWIC 2002). It largely follows from submissions by participants of the Working Meeting of the IUCN/SSC Polar Bear Specialist Group (2006), including the authors of this report for text related to Section 7.1, Table 6, and summaries of Nunavut subpopulations. We also include recently collected ATK and information presented at the Federal/Provincial/Territorial Polar Bear Technical Committees of 2006 and 2007 (PBTC 2006, 2007).

The world's population of polar bears is estimated to number some 20,000–25,000 animals, of which approximately 15,500 are in Canada or in subpopulations shared with Canada (Table 6). Because several subpopulations are shared internationally and each is managed independently, it is difficult to meaningfully discuss dynamics of a single "Canadian population" of polar bears (Figure 2, Section 3.3). Table 6 summarizes for each subpopulation current estimates of abundance, past trends in subpopulations, current human-caused mortality, and estimated current trajectories (annualized finite rates of increase, λ) and projections of trend where recent data on abundance and rates of survival and reproduction allow. Also presented are the zero-harvest estimates of λ for each subpopulation (i.e., estimated growth rate should harvest immediately cease). Projections of trend into the future (population viability analysis [PVA]) and current estimates of λ are based on simulation models using age- and sex-structured, stochastic population models presented for subpopulations using information on abundance, reproduction (Table 3), estimated harvest over the past 5 years, and estimated survival rates (Tables 4 and 5). Sections 7.2–7.14 present detailed information on the recent history and status of each Canadian subpopulation, including literature sources for data presented in Tables 3–6.

7.1 Status Table

Table 6 presents subpopulation sizes and uncertainty in estimates as 95% confidence intervals (CI). These estimates are based on scientific research using mark-recapture analysis, except where foot noted. The years in which data were collected are presented to provide an indication of the current reliability of subpopulation estimates. Where >1 estimate of abundance was available, the 2 latest estimates are presented. Note, however, that a difference in abundance from a previous to a current estimate may not necessarily entail any real increase or decrease in abundance, but rather a correction from a past under- or over-estimate of abundance. The past trend of subpopulations as suggested by the relevant citations of abundance are indicated as decline, stable, or increase.

For most subpopulations, harvesting of polar bears is regulated; hunting is by far the major cause of mortality for polar bears. In most jurisdictions, the total number of bears killed by humans in pursuit of sport and subsistence hunting, accident, and in defence of life or property are documented. Table 6 presents the 5-year means of known human-caused mortalities (removals) for each subpopulation (2002–2007).

For most subpopulations, recent quantitative estimates of abundance and parameters of natural survival, reproduction, and human kill are available to determine the current finite rate of increase ($\lambda \pm 1$ standard error [SE]) of the population (e.g., over the next 5 years). The computation of λ is an application of birth and death rates (and their uncertainty), carried out using the simulation model RISKMAN v. 1.9005 (Taylor *et al.* 2003). Values of $\lambda > 1.0$ indicate population growth and $\lambda < 1$ indicate population decline ($\lambda = 1.0$ suggests stability). Stated values are estimates of the current trend of a given subpopulation, which in some cases updates trend information obtainable from past and current estimates of abundance. These values are our best interpretation of the current, short-term trajectory of a subpopulation. For comparison, also presented for each subpopulation is the estimated λ under harvest moratorium. This value conveys the importance of harvest on determining current population trends, and instances of where climate change may have impacted survival rates to such an extent that subpopulations decline even without harvesting. We caution that estimates of λ cannot be averaged across subpopulations (i.e., to develop a population-wide rate of increase), as subpopulations are managed and modelled as unique demographic units, and assume no rescue effects or metapopulation dynamics (Hanski and Gilpin 1997).

We also used RISKMAN (Taylor *et al.* 2003) to estimate likelihoods of future subpopulation declines over 3 generations of polar bears (36 years; Section 5.1). The simulation model and documentation detailing the model's structure is available from: http://www.nrdpfc.ca/riskman/riskman.htm. Recent publications using the RISKMAN PVA model include Dobey *et al.* (2005), McLoughlin *et al.* (2005), Wear *et al.* (2005), Clark and Eastridge (2006), and Howe *et al.* (2007).

RISKMAN is designed to incorporate uncertainty into population simulations at several levels, including sampling error in initial subpopulation size, variance about vital rates due to sample size and annual environmental variation (survival, reproduction, sex ratio), and demographic stochasticity. RISKMAN uses Monte Carlo techniques to generate a distribution of results, and then uses this distribution to estimate population size at a future time, projected mean annual finite rate of population increase over the period involved, and proportion of runs that result in population decline set at a predetermined level by the user. We adopted the latter to estimate the probability of persistence.

Our approach to variance in simulations was to partition total variance of vital rates by a ratio of 3:1 sampling to environmental variation (Taylor *et al.* 2008a,b,c). We did this because variances for reproductive parameters often did not lend themselves to directly separating the sampling component of variance from environmental variance. Simulation results suggested that sampling error had a greater impact on population viability compared to environmental error, and so we weighted sampling error more heavily in the simulations to produce more conservative results. Differences based on weighting sampling vs. environmental error were minor, however (see Taylor *et al.* 2008a,b,c).

Individual runs could recover from "depletion", but not from extinction. Simulations also assumed no immigration or emigration among subpopulations. Because estimates of likelihood of decline were calculated without consideration of metapopulation dynamics (in particular rescue effects between subpopulations), overall results are more likely to indicate decline than is the case.

Simulations are presented using rates of survival and reproduction that were estimated within the past 10 years, and therefore assume effects of climate change leading to today's climatic conditions only. RISKMAN does not incorporate effects of directional environmental or habitat change on demographic parameters. Thus, regardless of length of simulation, results are relevant for near-term status assessment only.

We modelled PVA as the proportion of 2,500 simulation runs after 36 years resulting in a decline that is ≥30% from initial population size. This value is currently used by COSEWIC for distinguishing between Threatened and Special Concern status of designatable units (Appendix E3, COSEWIC Operations and Procedures Manual, draft dated April, 2005); however, as stated above, due to unknown effects of directional climate change on survival and recruitment, results should be used to interpret current and short-term likelihoods of decline only. Further, each modelled subpopulation is in itself not a Designatable Unit (Section 3.2). Note that persistence probabilities converge on a single percentage without error after running a large number of simulations (>1,000), and so no error estimate is applicable to likelihood of decline.

Required parameter and standard error inputs included: annual natural and/or total survival rates (stratified by age and sex as supported by the data; Tables 4 and 5), stratified rates of harvest if not using total survival rates (we used 5-year means; Table 6), data on reproduction (age of first reproduction, age-specific litter production rates for females available to have cubs [i.e., females with no cubs and females with 2-year-olds], and litter size; Table 3), and abundance (Table 6). We only used total survival rates (Table 4) if estimates were very recent and thus incorporated current harvest levels (i.e., those comprising the 5-year mean [2002–2007] for a subpopulation; Table 6). If harvest data had changed since collection of survival data, we modelled populations based on estimated natural survival (Table 5) from which the current age and sex-stratified hunting mortality was deducted.

The standing age distribution was female-biased for all subpopulations, likely due to harvesting of males. Because we wished to err on the side of caution, for all simulations we used the stable age distribution expected for the subpopulation at the anticipated annual removal rate as the initial age/sex distribution (i.e., by initializing the subpopulation at the stable age distribution, more conservative outcomes were produced compared to runs initialized at the current standing age distribution).

7.2 Southern Beaufort Sea

The subpopulation of polar bears inhabiting the Southern Beaufort Sea is shared between Canada and the United States (Alaska). On the Canadian side of the border, the historical harvest of bears has been relatively light. The subpopulation experienced an increase in hunting activity in the late 1950s due to an increase in fur prices (Usher 1976); however, by the mid-1970s polar bears were only killed opportunistically during hunts for other species by Aklavik and Inuvik hunters (Usher 1976). Hunters of Tuktoyaktuk recall people from their community also hunting polar bears during this time (Frank Pokiak, Chair, Inuvialuit Game Council, letter to COSEWIC Terrestrial Mammals Specialist Subcommittee, January 19, 2007). The Cape Bathurst area was reported to be an important area for hunting polar bears (Usher 1976).

During the early 1980s, radio-collared individuals were tracked from the Canadian portion of the Southern Beaufort Sea into the eastern Chukchi Sea of Alaska (Amstrup *et al.* 1986; Amstrup and DeMaster 1988). Telemetry data combined with re-sightings of tagged individuals suggested that bears of 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 (Amstrup *et al.* 1986; Amstrup and DeMaster 1988; Stirling *et al.* 1988). Recognition that bears were shared by Canada and Alaska prompted the *Polar Bear Management Agreement for the Southern Beaufort Sea* (the *Agreement*). The *Agreement*, between the Inupiat hunters of Alaska and the Inuvialuit hunters of Canada, was ratified by both parties in 1988. The *Agreement* included provisions to protect bears in dens and females with cubs, and stated that the annual sustainable harvest from the Southern Beaufort Sea would be shared between the 2 jurisdictions. Harvest levels were to be reviewed annually in light of the best scientific information available (Treseder and Carpenter 1989; Nageak *et al.* 1994). Brower *et al.* (2002) evaluated the effectiveness of the *Agreement* after the first 10 years and concluded that, overall, it had been successful in ensuring that the total harvest and the harvest of adult females remained within what were thought to be sustainable limits.

Amstrup *et al.* (1986) estimated the size of the Southern Beaufort Sea subpopulation to be approximately 1,800 bears in 1983, with a minimum and maximum of 1,300 and 2,500 bears, respectively. Research incorporating mark and recapture and radio-telemetry has continued on a nearly annual basis through to the present time. Capture-recapture models applied to data collected from 2001 to 2006 suggest that there were 1,526 (95% CI 1,211–1,841) polar bears in the region in 2006 (Regehr *et al.* 2006).

Rates of survival and recruitment have recently been developed for bears of the Southern Beaufort Sea (Regehr *et al.* 2006; 2007b; PBTC 2007; Tables 3–5). Given the current combined U.S.-Canadian harvest of bears in the Southern Beaufort Sea, the population is likely declining at the present time (Table 6). Importantly, should harvest be decreased to zero, there is a high likelihood that the population would continue to decline (Table 6).

7.3 Northern Beaufort Sea

Studies of polar bears in the Northern Beaufort Sea have used telemetry and mark and recapture programs at regular intervals since the early 1970s (Stirling *et al.* 1975, 1988; DeMaster *et al.* 1980; Lunn *et al.* 1995). Results suggested that there were separate subpopulations in the Northern and Southern Beaufort Sea areas and not a single subpopulation as was initially thought (Stirling *et al.* 1988; Amstrup 1995; Taylor and Lee 1995; Bethke *et al.* 1996). An abundance estimate of 1,200 polar bears in the late 1980s (Stirling *et al.* 1988) was believed to be unbiased, but is now dated. Stirling *et al.* (2007) updated both the previous and current estimates of abundance in the Northern Beaufort Sea, and conclude current stability in the population. Recent analyses, using data from satellite tracking of female polar bears and new spatial modelling techniques, indicate the boundary between the Northern Beaufort Sea and the Southern Beaufort Sea subpopulations may need to be adjusted, probably by expanding the area occupied by bears from Northern Beaufort Sea and reducing that of Southern Beaufort Sea (Amstrup *et al.* 2004).

Hunting of polar bears of the Northern Beaufort Sea has historically focused on the Amundsen Gulf (Usher 1976; Farquharson 1976), although the western coast and associated sea ice of Banks Island are also important for Inuit hunters (Usher 1976). Little ATK on the status of polar bears in this area has been recorded, but what is available supports this assertion. In a 2001 interview for the Paulatuuq Oral History project, an elder hunter suggested that the population in the area had been stable over the past 30 years (Parks Canada 2004).

Trend for this subpopulation is believed to be stable by Stirling *et al.* (2007), with abundance currently at 980 bears (95% CI: 825–1,135). Reported survival rates for some age groups (e.g., yearlings) have high variability and are unreasonably low (e.g., by half compared to cubs-of-the-year, and lower than ever reported in the literature; Table 4), precluding simulations based solely on North Beaufort data (Table 6). Lower than expected survival rates are likely due to unmodelled heterogeneity in the capture data.

7.4 Viscount Melville Sound

Only in the past 30 years have polar bears of the Viscount Melville Sound experienced regular hunting pressure. Farquharson (1976) noted that by the mid-1970s, hunters from the Holman area had expanded their traditional hunting range to kill polar bears along the western and northern coasts of Victoria Island to Glenelg Bay. At the same time, Inuit from Cambridge Bay began travelling by land or air to reach northern Victoria Island to hunt polar bears. In response to increased interest in hunting bears of the Viscount Melville Sound, the Government of the Northwest Territories established quotas. When quotas were originally allocated in the 1970s, the size and productivity of the Viscount Melville Sound subpopulation was overestimated. Polar bear density is lower in Viscount Melville Sound compared to other regions because of large expanses of multi-year ice and low densities of ringed seals (Kingsley *et al.* 1985). The consequence of overestimating abundance when initially setting quotas was substantial over-harvest of bears in the region during the 1980s and early 1990s (e.g., 1985–1990 mean of 19.6 bears/year; Taylor *et al.* 2002).

A 5-year moratorium on hunting was enacted in 1994/1995. Hunting resumed in 1999/2000 with an annual quota of 4 bears. In 2004/2005 the annual quota was increased to 7 bears/year (Northwest Territories 4, Nunavut 3) to accommodate hunters on both sides of the new territorial border. Polar bear numbers in the Viscount Melville Sound should be increasing with this increase in quotas (Table 6); however, the subpopulation remains at historically low levels and the abundance estimate is now becoming dated.

A 5-year study of movements and size of the Viscount Melville Sound subpopulation of polar bears using satellite telemetry and mark and recapture sampling was completed in 1992 (Messier *et al.* 1992, 1994; Taylor *et al.* 2002). Current boundaries are based on observed movements of females with satellite radio-collars and movements of bears tagged inside and outside of the study area (Bethke *et al.*

1996; Taylor *et al.* 2001). The published 1996 abundance estimate of 215 bears (SE = 58) in Taylor *et al.* (2002) was based on the 1993 estimate plus 3 years of simulated population growth. Polar bears in the Viscount Melville Sound are likely to benefit from a warming climate (at least over the short-term), which may increase the abundance and accessibility of seals by reducing amounts of multi-year ice.

7.5 Norwegian Bay

The polar bear subpopulation of Norwegian Bay is bounded by multi-year ice to the west, islands to the north, east, and west, and polynyas to the south (Taylor *et al.* 2001; Taylor *et al.* 2008b). Based on data from mark-recapture studies and satellite radio-tracking of adult females, it appears that most bears concentrate along coastal tide cracks and ridges in the northern, eastern, and southern regions of Norwegian Bay (Taylor *et al.* 2001). The preponderance of multi-year ice through most of the central and western areas contributes to low densities of ringed seals (Kingsley *et al.* 1985) and, consequently, low polar bear density. Grise Fiord hunters reported high concentrations of polar bears in Norwegian Bay during the early 1970s (Riewe 1976); however, based on unpublished data, the current (1993–97) estimate for this subpopulation is 190 bears (SE = 48.1; Taylor *et al.* 2008b). Estimates of survival rates (Tables 4 and 5) for Norwegian Bay are derived from pooled Lancaster Sound and Norwegian Bay data because these 2 subpopulations are adjacent and because the number of bears captured in Norwegian Bay was too small for reliable survival estimates (Taylor *et al.* 2008b). Risk of decline (Table 6) is high for this subpopulation because of a relatively low rate of reproduction (Table 3) and low abundance; however, polar bears in Norwegian Bay are likely to benefit from a warming climate (at least over the short term) which may increase abundance of and accessibility to seals. The harvest quota for the Norwegian Bay subpopulation was reduced to 4 bears (3M:1F) in 1996 and remains at this level today. The population is probably stable at the current time but there is substantial incertitude about its trend.

7.6 Lancaster Sound

The central and eastern portion of the Lancaster Sound subpopulation is characterized by high productivity and thus high densities of ringed seals and polar bears (Schweinsburg *et al.* 1982; Kingsley *et al.* 1985; Welch *et al.* 1992). Inuit hunters of Resolute, Grise Fiord, and Arctic Bay have all historically hunted polar bears in Lancaster Sound (Brody 1976; Riewe 1976). The western third of this region (eastern Viscount Melville Sound) is dominated by multi-year ice and apparently low biological productivity, leading to low densities of ringed seals (Kingsley *et al.* 1985). In the spring and summer, densities of polar bears in the western third of the area are low; however, as break-up occurs, polar bears move west to summer on the multi-year pack.

Mark-recapture data and data on movements of adult females fitted with satellite radio-collars have been collected for bears of Lancaster Sound (Taylor *et al.* 2001, 2008b). The current abundance estimate of 2,541 bears (SE = 391) is based on an analysis of mark-recapture data current to 1997 (Taylor *et al.* 2008b). This estimate is considerably larger than the 1979 estimate of 1,031 ± 236 bears (mean ± 95% CI) published by Schweinsburg *et al.* (1982); however, given the substantial differences in study area boundaries between Schweinsburg *et al.* (1982) and Taylor *et al.* (2008b), it is difficult to compare estimates. Schweinsburg *et al.* (1982) focused on a much smaller area that extended into northern Baffin Bay, compared to the bounds used by Taylor *et al.* (2008b) and presented in Figure 2. Recent survival rates of polar bears Lancaster Sound are presented by Taylor *et al.* (2008b). Note that Taylor *et al.* (2008b) pooled the similar survival rates of Lancaster Sound with those of Norwegian Bay to minimize sampling errors (Tables 4 and 5).

7.7 M'Clintock Channel

The current boundaries for the M'Clintock Channel subpopulation are based on recoveries of tagged bears and movements of adult females with satellite radio-collars in adjacent areas (Taylor and Lee 1995; Taylor *et al.* 2001). These boundaries appear to be a consequence of large islands to the east and west, the mainland to the south, and the multi-year ice in Viscount Melville Sound to the north. A 6-year mark-recapture study in the mid-1970s covered most of this area (Furnell and Schweinsburg 1984). An estimate of 900 bears was derived from data collected within the boundaries proposed for the M'Clintock Channel subpopulation from results of Furnell and Schweinsburg (1984), who identified an abundance estimate of 1,100 animals for an area that overlapped both M'Clintock Channel and the Gulf of Boothia. After the study was published, local hunters suggested the estimate of 900 animals may have been too high; hence, the Federal/Provincial/Territorial Polar Bear Technical Committee accepted a recommendation to reduce the abundance estimate to 700 bears (M.K. Taylor, Department of Environment, Government of Nunavut), which would have been current to 1978 (i.e., the last year of Furnell and Schweinsburg's sampling program). No accurate confidence intervals are available for this estimate.

Following completion of a mark-recapture inventory in spring of 2000, the subpopulation was estimated to number only 284 bears (SE = 59.3; Taylor *et al.* 2006a). The legal harvest (averaging 34.0 bears/year from 1979–1999) for M'Clintock Channel was clearly unsustainable. The Government of Nunavut implemented a moratorium on hunting for the 2001/2002 and 2002/2003 hunting seasons. The current annual quota for M'Clintock Channel is 3 bears and the population is now likely growing (Table 6); however, the subpopulation remains at risk due to low abundance.

Scientific data which suggests low abundance of polar bears in M'Clintock Channel due to over-harvest is supported by ATK. Recently, hunters of Gjoa Haven reported that the number of bears near their community has declined over the past 30 years (Keith *et al.* 2005). Other areas where decreased numbers of polar bears have been reported include the Royal Geographical Society Islands, Pasley Bay, northern King William Island, Gateshead Island, Larsen Sound, and the M'Clintock Channel itself (Atatahak and Banci 2001). Inuit suggest that polar bears are no longer present in the Queen Maud Gulf area (Keith *et al.* 2005). Inuit hunters also report a decline in the number of adult male bears in M'Clintock Channel but that large males can be found further to the north (Atatahak and Banci 2001; Keith *et al.* 2005). This finding is consistent with what one could expect from a relatively heavy, male-biased hunt. Northern M'Clintock Channel is the recent focus of the polar bear hunt out of Gjoa Haven (Keith *et al.* 2005).

In addition to unsustainable harvesting, recent changes in habitat and disturbance by humans have been identified by Inuit as potential reasons for the reduced abundance of bears in M'Clintock Channel (Keith *et al.* 2005). One noted habitat change has been the recent absence of multi-year ice and icebergs, although this may offer improved habitat for ringed seals and so may not necessarily be detrimental to polar bears. Human disturbances such as the construction of DEW (Distant Early Warning) line sites, construction of Inuksuit, and noise from aircraft and snowmobiles are also thought to have contributed to the low density of bears around Gjoa Haven (Keith *et al.* 2005).

7.8 Gulf of Boothia

Boundaries of the subpopulation of polar bears inhabiting the Gulf of Boothia were largely based on movements of tagged bears (Taylor and Lee 1995), movements of collared females in the Gulf of Boothia and adjacent areas (Taylor *et al.* 2001), and information from Inuit hunters about how local conditions influence the movements of polar bears. Distinction between the Gulf of Boothia and M'Clintock Channel subpopulations of polar bears has, however, recently been questioned by Inuit hunters (Keith *et al.* 2005), and new genetic analyses (Saunders 2005) suggest considerable interchange between the subpopulations.

Hunting in the Gulf of Boothia increased from historic levels through the 1970s (Brice-Bennett 1976); however, unlike the situation in Viscount Melville Sound and M'Clintock Channel, the original quota established by the Government of the Northwest Territories in the Gulf of Boothia was likely less than the maximum sustainable yield. Local hunters reported that the subpopulation increased during the 1980s after results of Furnell and Schweinsburg (1984) suggested abundance at around 300 bears (considering that portion of the Gulf of Boothia included in their study area). Based on Inuit knowledge, recognition of past sampling deficiencies, and an increased understanding of polar bear densities in other areas, the interim subpopulation estimate in the 1990s for the Gulf of Boothia was 900 bears (M.K. Taylor, Department of Environment, Government of Nunavut). Following completion of a mark-recapture inventory in spring of 2000, the subpopulation was estimated to number 1,528 bears (SE = 285; Taylor *et al.* 2008c). Recruitment and survival rates (Tables 3–5) were estimated to be relatively high. The subpopulation is considered to be growing (Table 6), and in 2005 harvest quotas were increased by the Government of Nunavut to 74 bears/year. Hunting success rates are reported to be high, although this does not convey information about status (personal communication of Kotierk [2005]).

7.9 Foxe Basin

Based on 12 years of mark-recapture studies, tracking of female bears with conventional radios, and satellite tracking of adult females in Western and Southern Hudson Bay, the Foxe Basin subpopulation is thought to comprise a demographic unit in Foxe Basin, northern Hudson Bay, and the western end of Hudson Strait (Taylor and Lee 1995). During the ice-free season, polar bears concentrate on Southampton Island and along the Wager Bay coast; however, significant numbers of bears also occur on the islands and coastal regions throughout the Foxe Basin area. Crête *et al.* (1991) found relatively few bears of the Foxe Basin population along the Quebec shore during the ice-free season. A total abundance estimate of 2,119 (SE = 349) was made in 1996 (M.K. Taylor, Department of Environment, Government of Nunavut, unpubl. data) from a mark-recapture analysis based on tetracycline biomarkers (Taylor and Lee 1994; M.K. Taylor, Department of Environment, Government of Nunavut, unpubl. data). The marking effort was conducted during the ice-free season, and distributed throughout the entire area. The abundance estimate is believed to have been accurate, but is now dated. Simulation studies suggest that harvest quotas prior to 1996 reduced the subpopulation from approximately 3,000 in the early 1970s to 2,100 bears in 1996. Harvest levels were reduced in 1996 to permit recovery of this subpopulation, provided that harvest in Quebec did not increase.

Recent ATK suggests that the subpopulation of Foxe Basin has increased since 1996 (McDonald *et al.* 1997). For example, at Southampton it has become not unusual for hunters to fill their quota in a matter of days (McDonald *et al.* 1997). However, ATK from the Ivujivik area indicates a decrease in polar bear numbers. One hypothesis proposed to explain this observation is that ocean currents in the region are now weaker, allowing bears to become distributed more evenly on the ice during mid-winter rather than congregating at the mouth of Hudson Strait (McDonald *et al.* 1997). After consultations with native communities, Nunavut increased the harvest quota in 2004 to a level consistent with a subpopulation size of 2,300 bears (109 bears/year). Co-management discussions with Quebec are ongoing.

Effects of climate change on the Foxe Basin subpopulation of polar bears have not been evaluated scientifically. Because Foxe Basin is immediately north of Western Hudson Bay and has experienced earlier timing of break-up of sea ice in similar fashion as the rest of Hudson Bay, future analyses might detect negative impacts on polar bears.

7.10 Western Hudson Bay

The distribution, abundance, and boundaries of the Western Hudson Bay subpopulation of polar bears have been studied since the late 1960s (e.g., Stirling *et al.* 1977; Derocher and Stirling 1990, 1992, 1995a,b; Taylor and Lee 1995; Lunn *et al.* 1997, 2006). Between 60–80% of adults have been marked at any given time and there are extensive records from mark-recapture studies and the return of tags from bears killed by Inuit hunters, and from the ongoing and long-term Polar Bear Alert Program of the Government of Manitoba. This population appears to be geographically segregated during the open-water season, although it mixes with those of Southern Hudson Bay and Foxe Basin on the Hudson Bay sea ice during the winter and spring (Stirling *et al.* 1977; Derocher and Stirling 1990; Stirling and Derocher 1993; Taylor and Lee 1995).

ATK of Inuit elders concerning polar bears in Western Hudson Bay has recently been summarized by Nirlungayuk (2008). Nirlungayuk (2008) suggests that polar bear abundance in the areas of Western Hudson Bay are today considerably higher than in the historic past (50+ years ago), and that this may have been the result of supplemental feeding by garbage (around Churchill). For example, prior to the increase in the population of humans in Churchill in the 1940s, polar bears were best hunted nearer Wager Bay, Southampton Island, and Coates Island; after polar bear hunting regulations came in if people wanted to be guaranteed a polar bear, they would travel down to south of Arviat. Observing polar bear dens by boat in Western Hudson Bay was once a rare event; now “lots of bears are there.” Concurrently but contrary to the scientific re-assessment of abundance (below), Inuit along the western coast of Hudson Bay recently reported seeing greater numbers of polar bears, which they interpreted as evidence of an increasing population (McDonald *et al.* 1997; Dowsley and Taylor 2006b). Polar bears have been reported as numerous at Chesterfield Inlet in September and have been increasing in that area since 1988. Bears have been present for several years near Arviat, from September to December, but have recently increased in number according to ATK, especially in September.

The dangers posed by polar bears in the region are a concern to Inuit, and what is thought by some to be an artificially high number of bears is viewed as a problem (Nirlungayuk 2008). Encounters in the region have increased through the 1970s and 1980s; since the 1980s the Arviat community has been giving warnings to hunters that persons should not go out alone for fear of polar bears. Nunavut Tunngavik Incorporated (NTI) recently collaborated with 5 experienced hunters from communities in Western Hudson Bay to complete a series of interviews and a workshop (NTI 2005). While the final analysis and report are not yet complete, the ATK data indicate an increasing number of bears in the Arviat area since the 1970s, and around Whale Cove and Rankin Inlet since the 1980s. This has also been noted by Inuit of Chesterfield Inlet. In Arviat, the recent increase has been noted in all seasons except winter, while Inuit of other areas report an increase in all seasons. In the Chesterfield Inlet area, groups (gatherings) of polar bears have been observed recently, something that was apparently rare in the past.

Over the past 30 years, the condition of adults and the proportion of independent yearlings caught during the open-water season have declined significantly in Western Hudson Bay (Derocher and Stirling 1992, 1995b; Stirling and Lunn 1997; Stirling *et al.* 1999; N. Lunn and I. Stirling, unpubl. data presented in IUCN/SSC Polar Bear Specialist Group 2006). Over the same period, the average date of break-up of the sea ice has advanced by 3 weeks (Stirling *et al.* 1999, 2004; Ferguson *et al.* 2005), probably due to increasing spring air temperatures (Section 6.1). Stirling *et al.* (1999) documented that the earlier the timing of break-up, the poorer the condition of adult females. Inuit are intimate with the changing ice conditions in Western Hudson Bay (Nirlungayuk 2008).

The number of polar bears in Western Hudson Bay was most recently assessed scientifically by Regehr *et al.* (2007a). Regehr *et al.* (2007a) show that abundance has declined from 1,194 (95% CI = 1,020–1,368) to 935 (95% CI = 794, 1,076) between 1987 and 2004, a reduction of approximately 22%. Progressive declines in the condition and survival of cubs, subadults, and bears 20 years of age and older likely initiated decline in the size of the subpopulation. It is believed that once the subpopulation began to decline, the existing harvest was no longer sustainable so that its additive contribution to the reduction in the size of the subpopulation accelerated between 1988 and 2004. The harvest sex ratio of 2M:1F in Western Hudson Bay has resulted in a sex ratio that is 58% female and 42% male (Derocher *et al.* 1997).

In summer 2007, the Government of Nunavut conducted a mark-recapture survey of bears from Churchill to Chesterfield Inlet to determine whether or not there were large numbers of bears along the Kivalliq coast during the summer as suggested by ATK (Peacock and Taylor 2007). The survey included those areas identified by ATK as being areas where polar bears were becoming more common. A total of 25 bears were captured during the 3-day survey. The proportion of marked individuals in the capture sample (p = 0.46, SE = 0.11) was lower but not statistically different from the proportion of marked animals in the Canadian Wildlife Service (CWS) capture sample (p = 0.59, SE = 0.01). Statistical power was low for this analysis. Results suggest that actual numbers of bears in Western Hudson Bay and annual survival rates could thus be slightly but not significantly higher (due to unmodelled heterogeneity) than estimated by Regehr *et al.* (2007a). Peacock and Taylor (2007) recommend that in future years, CWS capture teams work north to Arviat to capture polar bears in the entire area where polar bears summer, but do not contest the conclusions of Regehr *et al.* (2007a).

Climate change in connection with over-harvest is the major threat to the Western Hudson Bay subpopulation. The population is believed to be declining at a substantial rate (Table 6), and the quota for hunting polar bears in Western Hudson bay is proposed to be reduced to 8 animals in 2008–2009.

7.11 Southern Hudson Bay

Inuit hunting the Southern Hudson Bay subpopulation of polar bears reported an increase in the number of bears that have historically occurred in the area (McDonald *et al.* 1997). The offshore islands of eastern Hudson Bay apparently had no bears 50 years ago, and the species was rare around Inukjuak, only appearing "recently" (McDonald *et al.* 1997). Similarly, in Sanikiluaq, it was rare to kill a polar bear in the 1960s but now the community's annual quota is filled in approximately 3 weeks, with increased observations of bears coming into the community (personal communication of Arragutainaq [2006]). In 1986, Crête *et al.* (1991) found relatively high numbers of bears near Twin Island in James Bay during the ice-free season. Cree in western James Bay report increased aggressiveness among bears and an increase in litter size (McDonald *et al.* 1997). Communities along the Hudson Bay and James Bay coasts in Ontario report an increase in bear encounters and property damage caused by polar bears (personal communications of Carpenter [2006]; Solomon [2006]; Kapashesit [2006]). In the past 5 years, polar bears have also been observed to travel more frequently during the open water season all the way to the Moosonee area of southern James Bay (approximately 1 sighting per year). Previously, bears were observed around Moosonee roughly once in 5 or 6 years (personal communications of Kapashesit [2006]; Solomon [2006]). Explanations offered for observations of higher numbers of bears include potential immigration of bears in response to increased ringed seals in the region, an extended ice floe in the area, and hunting quotas below the maximum sustainable yield.

Boundaries of the Southern Hudson Bay subpopulation of polar bears are currently based on data from movements of marked bears of all sexes and telemetry studies of females (Jonkel *et al.* 1976; Kolenosky and Prevett 1983; Kolenosky *et al.* 1992; Taylor and Lee 1995). Crompton (2004) suggests that the current boundaries that define the Southern Hudson Bay subpopulation may need to be revisited, as she observed at least three breeding groups in the southern portion of Hudson Bay (including James Bay).

Results of Obbard *et al.* (2007) suggest that contrary to results coming from Western Hudson Bay (Section 6.1, 7.10)—although not suggesting a large increase consistent with ATK (above)—there has been no observable decline in abundance of polar bears in Southern Hudson Bay since the 1980s. A recent analysis of data presented in Kolenosky *et al.* (1992) using new mark-recapture software estimated abundance of polar bears in Southern Hudson Bay as 641 (95% CI: 401–881) in 1986 and 681 (95% CI: 401–961) in 2005. These estimates are lower than previously stated for the Southern Hudson Bay (e.g., 1,000 bears), and are likely an underestimate because of lack of complete coverage of the population (e.g., areas in James Bay). Stirling *et al.* (2004), in their recent analysis of coastal survey data, also suggested that the abundance of polar bears in Southern Hudson Bay has remained unchanged in recent years.

Stirling *et al.* (1999) contend that climate-related reductions in sea ice appear to have resulted in declines in body condition and in reproduction in the adjacent Western Hudson Bay subpopulation of polar bears (Sections 6.1 and 7.10). A similar pattern of decline in body condition was documented for the Southern Hudson Bay subpopulation when comparing bears captured in 1984–1986 with those captured in 2000–2004 (Obbard *et al.* 2006, 2007; PBTC 2006). Lucassie Arragutainaq of Sanikiluaq reported in August, 2006 (Arragutainaq 2006) that, although the animals look healthy and have nice fur, the fat of polar bears in the area no longer has the same consistency as in years previous. Although overall abundance in Southern Hudson Bay appears to have been stable since the 1980s, it is unknown to what extent changes in body condition might impact demographic parameters and thus abundance in the future.

7.12 Kane Basin

Based on movements of adult females equipped with satellite radio-collars and recaptures of tagged animals, the boundaries of the Kane Basin subpopulation include the North Water Polynya (to the south), and Greenland and Ellesmere Island to the west, north, and east (Taylor *et al.* 2001). Polar bears in Kane Basin do not differ genetically from those in Baffin Bay (Paetkau *et al.* 1999; Tables 1 and 2). Prior to 1997, this subpopulation was essentially unharvested in Canadian territory because of its distance from Grise Fiord, the closest Canadian community, and because conditions for travel in the region are typically difficult. However, bears from this subpopulation have occasionally been harvested by hunters from Grise Fiord (since 1997) and harvest continues on the Greenland side of Kane Basin. In some years, Greenland hunters also harvest polar bears in western Kane Basin and Smith Sound (Rosing-Asvid and Born 1990).

Few polar bears were encountered along the Greenland coast between 1994 and 1997, possibly because of harvest pressure by Greenland hunters. The current and only estimate of the Kane Basin subpopulation is 164 bears (SE = 35; Taylor *et al.* 2008a). The best estimate of the Greenland kill is 10 bears/year during 1999–2003 (Born 2005; Born and Sonne 2005). However, the actual number being taken by Greenland hunters is uncertain (Rosing-Asvid 2002; Born and Sonne 2005) and needs to be validated. The Canadian quota for this subpopulation is 5 bears/year. The annual combined Canadian and Greenlandic take of 10–15 bears from this subpopulation is unsustainable (Table 6). Although the habitat appears suitable for polar bears on both the Greenland and Canadian sides of Kane Basin, the density of bears on the Greenland side is much lower than on the Canadian side.

Co-management discussions regarding the hunting of polar bears have been ongoing between Greenland and Canada. Greenland enacted a quota system on January 1, 2006 (West Greenland harvest is not to exceed 100 bears/year, PBTC 2006); however, because Kane Basin, Baffin Bay (Section 7.13), and Davis Strait (Section 7.14) are treated as a single unit for management purposes by Greenland, it is unclear whether reductions in the harvest of bears in Kane Basin will result from the establishment of this quota. The mean kill of polar bears in Kane Basin has been 10 bears/year for hunters of Greenland in recent years, and <1 for hunters of Nunavut (PBTC 2006).

7.13 Baffin Bay

Based on movements of adult females equipped with satellite radio-collars and recaptures of tagged animals, the area in which the Baffin Bay subpopulation occurs is bounded by the North Water Polynya to the north, Greenland to the east, and Baffin Island to the west (Taylor and Lee 1995; Taylor *et al.* 2001). A relatively distinct southern boundary at Cape Dyer (Baffin Island) is evident from the movements of tagged bears (Stirling *et al.* 1980) and recent movement data from polar bears monitored by satellite telemetry (Taylor *et al.* 2001). A study of micro-satellite variation did not reveal any genetic differences between polar bears in Baffin Bay and Kane Basin, although bears of Baffin Bay differed significantly from those of Davis Strait and Lancaster Sound (Paetkau *et al.* 1999; Tables 1 and 2). An initial subpopulation estimate of 300–600 bears was made by the Government of the Northwest Territories from mark-recapture data collected in spring of 1984–1989. However, recent work has since shown that an unknown proportion of the subpopulation was typically offshore during the spring and, therefore, unavailable for capture. A second study (1993–1997) was carried out annually during the months of September and October, when all polar bears were on shore in summer retreat areas on Bylot and Baffin islands (Taylor *et al.* 2005). Taylor *et al.* (2005) estimated the number of polar bears in Baffin Bay (1998 estimate) at 2,074 bears (SE = 266).

The Baffin Bay subpopulation of polar bears is shared with Greenland, which until January 2006, did not limit the number of bears killed in a year. Based on mark-recapture sampling, Taylor *et al.* (2005) estimated the Greenland annual removal at 18–35 bears for the period 1993–1997. However, Born (2002) reported that the estimated Greenland average annual catch of polar bears from Baffin Bay was 73 bears/year over the period 1993–1998. Greenland documents that the average kill by Greenland hunters in Baffin Bay for the period 2002–2007 was 147 bears/year (range: 75–206 bears/year; PBTC 2008).

The 2004 estimate of <1,600 bears is based on population simulations (similar to the most recent estimates of abundance in Viscount Melville Sound and M'Clintock Channel; Sections 7.4 and 7.7) that employed the pooled Canadian and Greenland harvest records since 1998 (Table 6; PBTC 2006, 2007). Greenland adopted a quota system effective January 1, 2006, which should see the elimination of extremely high harvests like that of 2002/2003 (206 polar bears). However, assuming that 75–85 bears taken per year in Baffin Bay will comprise the 100-bear West Greenland quota (historical Greenlander harvest of bears in Kane Basin and Davis Strait has been 5–25 and <5 bears, respectively [PBTC 2008]; last year's Greenlander take in Baffin Bay under the new quota was 75 bears), the current Nunavut-Greenland harvest will equal approximately 185 bears/year. Simulations suggest that this level of hunting will continue to deplete the subpopulation (Table 6, Taylor *et al.* 2005).

Contrary to scientific estimates and similar to the situation in Western Hudson Bay (Section 7.10), Inuit have reported higher abundances of polar bears in Baffin Bay in recent years. ATK from 3 Baffin Bay communities (Pond Inlet, Clyde River and Qikiqtarjuaq) indicates that hunters and residents have been seeing more polar bears on the land and around communities in the past few years compared to 10–15 years ago (Dowsley 2005). Significantly more people in the 2 northern communities experienced this increase compared to people in Qikiqtarjuaq (Dowsley 2005). Bear encounters have increased, especially in Pond Inlet and Clyde River, and safety concerns have grown, as well as concerns about damaged property (Dowsley and Taylor 2006a). In response to community suggestions that polar bears increased in abundance in recent years, the Government of Nunavut increased its quota in Baffin Bay from 64 to 105 bears in December of 2004.

Despite the above, the best available scientific information suggests the Baffin Bay subpopulation is substantially over-harvested. The discrepancy between ATK and scientific data regarding the trajectory of the Baffin Bay subpopulation of polar bears is a matter of concern. Local observations of increased abundance may again be due to higher levels of bear activity in response to increased time spent on-shore by polar bears in response to climate warming in the region (Sections 6.1 and 6.2). Movements inland during summer have apparently increased in places in recent years. For example, Inuit have reported that during the open-water season bears can be found much farther into Eclipse sound, up the fiords and inlets where they did not previously occur (Dowsley 2005). Further, all 3 Baffin Bay communities have reported climate change impacts on the sea ice, such as less shore-fast ice, fewer icebergs and thinner ice, which some people (5/12 people who discussed the idea) thought might contribute to changes in polar bear distribution (Dowsley 2005; Dowsley and Taylor 2006a).

7.14 Davis Strait

Based on movements of tagged animals and, more recently, of adult females with satellite radio-collars, the Davis Strait subpopulation is comprised of bears from the Labrador Sea, eastern Hudson Strait, Davis Strait south of Cape Dyer, and along the eastern edge of the Davis Strait-southern Baffin Bay pack ice (Taylor *et al.* 2001). When bears occur in the latter area they are subject to hunting by Greenlanders (Stirling and Kiliaan 1980; Stirling *et al.* 1980; Taylor and Lee 1995; Taylor *et al.* 2001).

The initial subpopulation estimate of 900 bears for Davis Strait (Stirling *et al.* 1980) was based on a subjective correction from a mark-recapture estimate of 726 bears, which was felt to be too low. Densities of bears were substantially higher in eastern Davis Strait than in the Foxe Basin subpopulation in the survey of the Quebec coast by Crête *et al.* (1991). In 1993, the Federal/Provincial/ Territorial Polar Bear Technical

Committee increased the estimate to 1,400 bears to account for bias in sampling created by the inability of researchers to survey the extensive area of offshore pack ice (M.K. Taylor, Department of Environment, Government of Nunavut). A population inventory by the Governments of Nunavut and Newfoundland and Labrador commenced in 2005. Following 2 years of mark-recapture sampling, a sex/age stratified Lincoln/Peterson estimate of 2,100 bears was developed (Peacock *et al.* 2006), which is presented in Table 6. No confidence limits are available for this estimate. The population inventory that was begun in summer of 2005 will conclude in summer 2007. Rates of survival and recruitment and final abundance estimates with confidence intervals will be available sometime in 2008.

Within Canada, bears of Davis Strait have traditionally been harvested by Inuit from Nunavut, Quebec, and Labrador (e.g., Kemp 1976; Val 1976; Brice-Bennett 1977; Brazil and Goudie 2006). The combined harvest by these jurisdictions averaged 58.6 over the past 5 years (Table 6). The Greenlander take for this subpopulation remains relatively low (1–11 bears/year in the past 5 years; PBTC 2007). Co-management discussions between Greenland and Canada are continuing, and Greenland has indicated its quota for Davis Strait will be 2 bears/year.

Qualitative observations from elders with considerable knowledge of polar bears in Nain indicated that abundance in Davis Strait was higher now than in the past (Nunatsiavut Government 2006); however, these elders also report that polar bear distribution has changed from primarily coastal and offshore areas to now also include the inland portions of bays (which freeze first), so that bears occur farther inland than previously. How climate change may be impacting polar bears in Davis Strait, and whether Inuit suggestions of higher abundances may contradict scientific estimates of trends in abundance as in Western Hudson Bay and the adjacent Baffin Bay, is unknown. However, like all areas where there is complete loss of sea ice in summer (Figure 5), increased the length of the open-water season due to climate warming is a concern for bears of Davis Strait.

8. SPECIAL SIGNIFICANCE OF THE SPECIES

The polar bear is the only terrestrial carnivore to occupy the highest trophic level of a marine ecosystem. The species has evolved unique adaptations to hunt seals from a sea-ice platform. Polar bears are of great cultural significance to the Canadian people, and are also important spiritually and economically to northern native peoples. As a symbol of the pristine Arctic environment, polar bears are seen throughout the world as a barometer of important environmental issues, especially climate change and pollution. Canada has national and international responsibilities with respect to the study, management, and protection of polar bears. This obligation is particularly important to our nation because we collectively manage 55–65% of the world's polar bears.

9. EXISTING STATUS DESIGNATIONS AND PROTECTIONS

9.1 International Status Designations and Protections

Internationally, polar bear research and management are coordinated under the *Agreement on the Conservation of Polar Bears* which was signed in November 1973 and came into effect on May 26, 1976 (also see Stirling 1988a; Prestrud and Stirling 1994). It prohibits unregulated sport hunting of polar bears and obliges each signatory to conduct research relating to the conservation and management of the species, the results of which are conveyed to each member nation. Member scientists of the Polar Bear Specialist Group meet every 3 to 4 years under the auspices of the IUCN World Conservation Union to coordinate research throughout the Arctic. Although responsibility for management of polar bears in Canada lies with the provinces and territories, the federal government on behalf of all jurisdictions signed the *Agreement*. Under the terms of the *Agreement*, the taking of polar bears is restricted to "local people" (which is interpreted in Canada to mean Aboriginal people or sport hunters guided by Aboriginal people) who harvest by traditional means and in accordance with sound conservation practices based on the best available scientific data. This *Agreement* was renewed indefinitely in 1981.

The polar bear was moved into a status of Vulnerable (equates to COSEWIC Threatened) from the status of Least Concern for the 2006 Red List of the Species Survival Commission (SSC) of the IUCN-The World Conservation Union (IUCN/SSC Polar Bear Specialist Group 2006; IUCN 2006). This move was in response to modelling of trends in sea ice extent, thickness, and timing of coverage which predicted dramatic reductions in seasonal sea ice coverage over the next 50 to 100 years due to climate warming (IUCN 2006), and recent demonstrations of and hypothesized impacts on polar bears (see Sections 4.2, 6 and 7). The reassessment was based on an expected worldwide reduction in polar bear numbers of at least 30% over the next 45 years, manifest in declines in area of occupancy and extent of occurrence (IUCN/SSC Polar Bear Specialist Group 2006). The uplisting recommendation was made given available data at the time and by unanimous consent by participating members at the IUCN/SSC Polar Bear Specialist Group Meeting in Seattle, WA, in June 2005.

Polar bears are listed under Appendix II of CITES (*Convention on International Trade in Endangered Species of Wild Flora and Fauna*). Under CITES, any international shipment of polar bears or parts thereof requires a permit. Since July 1975, a permanent record of all polar bears, hides, or any other products legally exported from or imported to Canada has been maintained by the Government of Canada. The U.S. Secretary of the Interior announced on May 14, 2008, that the polar bear will be listed as Threatened under the U.S. *Endangered Species Ac*t.

9.2 Canadian Status Designations and Protections

Conservation and management of polar bears in Canada involves more than 10 agencies: 4 provinces, 3 territories, the federal government, plus the management boards established by land settlement claims. Discussion between jurisdictions to facilitate management decisions is co-ordinated by their Wildlife Directors and the Federal/Provincial/Territorial Polar Bear Technical Committee (PBTC). The PBTC includes biologists from each jurisdiction and invited experts from user groups and other research organizations (such as universities) who have expertise with ATK or scientific research on polar bears. Each year, the PBTC, reporting to the Polar Bear Administrative Committee (PBAC), discusses the most recent research results to make recommendations on protection measures for the species to senior administrators and user groups.

In Canada, the PBTC conducts an annual review of the status of each subpopulation of polar bears and its sustainable harvest, and monitors the annual kill. The sustainable harvest of independent female polar bears (i.e., 2 years of age and older) for each subpopulation was, in the mid-1980s, estimated to be about 1.5% for most subpopulations (Taylor *et al.* 1987). These estimates of sustainable yield, which included the need to maintain a 2 male to 1 female sex ratio in the harvest, have been the basis for developing most quotas in Canada for the past 15 years (see Taylor *et al.* 2008d).

How harvests are currently allocated among subpopulations is a matter of debate. For example, the Government of Nunavut recently increased the combined harvest quota for the 12 subpopulations of polar bears found within the territory from 403 in 2004 to 518 in 2005, largely based on the perception by Inuit that some subpopulations increased under the historical harvest regimen (IUCN/SSC Polar Bear Specialist Group 2006; PBTC 2006). Although some increases in quotas have been supported by the findings of mark-recapture analyses (e.g., Gulf of Boothia; Taylor *et al.* 2008c), quota increases based on Inuit perceptions have also included harvests for subpopulations documented by western science to be in steep decline (e.g., Western Hudson Bay and Baffin Bay, see Sections 6, 7.10, and 7.13).

Within Canada, while the governments of the provinces and territories have the authority for management, the decision-making process for some is shared with Aboriginal groups as part of the settlement of land claims. For example, the Inuvialuit have exclusive rights to harvest polar bears in the Yukon. Management of polar bears is coordinated through the Yukon and Northwest Territories governments and the Inuvialuit co-management boards established under the *Inuvialuit Final Agreement* (IFA). In most Canadian jurisdictions, hunting seasons, quotas, and protection of family groups are enforced by law; only Manitoba prohibits the hunting of polar bears. Over 80% of the hunting of polar bears in Canada occurs in Nunavut and the Northwest Territories, where management agreements and/or memoranda of understanding have been developed with local communities with the aim to ensure that all human-caused mortality is within the suggested sustained yield.

In Manitoba, polar bears are protected under the *Wildlife Act* and there is no hunting season. This designation also removes the right to kill polar bears under Aboriginal treaty rights. Bears may only be killed in defence of life or property.
The province of Manitoba recently listed polar bears as a Threatened Species.

The polar bear is listed as a species of Special Concern on the Species at Risk List of the *Ontario Endangered Species Act*. Polar bears are also protected under the *Ontario Fish and Wildlife Conservation Act*, and there is no hunting or trapping season. Notwithstanding, Aboriginal people under Treaty #9 and interpreted as residing along the Hudson Bay and James Bay coast are permitted to harvest polar bears, including females with cubs and bears in their dens. Harvest reporting is voluntary in Ontario but is considered to be generally reliable because polar bear skins may not be sold until they have been sealed by the province. Quotas for each community that harvests polar bears have been enforced by the denial of seals to enable legal sale of hides and carrying over of seals to the next harvesting year (thereby reducing the following year's quota). Current quotas, however, are based on dated and inaccurate information and assumptions (M. Obbard, Ontario Ministry of Natural Resources, Government of Ontario, letter to COSEWIC Terrestrial Mammals Specialist Subcommittee, February 1, 2007).

In Quebec, the polar bear is listed as “likely to become threatened or vulnerable,” according to the *Liste des Espèces Fauniques Menacées ou Vulnérables au Québec*, and legal designation is under review at the time of writing. Notwithstanding the potential for future changes in provincial designation, under the *James Bay Agreement* Inuit are allocated a “guaranteed harvest” of 62 bears annually. This means that the first 62 bears of an estimated sustainable harvest would be reserved for the exclusive use of Aboriginal people. This number is subject to conservation limitations, however, so if the sustainable level was determined to be less than 62, the lower number would prevail and all the animals taken would be guaranteed for Aboriginal use only. The guaranteed harvest level was determined solely from harvest statistics and was not based on an estimate of sustainable yield from a population estimate. The *James Bay Agreement* was signed in 1975, before it was realized that Aboriginal hunters from Quebec harvested bears from 3 different subpopulations (i.e., Southern Hudson Bay, Foxe Basin, and Davis Strait). There are no quotas currently in effect in Quebec although Aboriginal hunters have agreed to limit harvesting to current levels until assessments are done for the 3 subpopulations from which they harvest bears. When assessments have been completed and sustainable harvests have been determined, Quebec hunters are expected to enter into co-operative management agreements with other user groups that share each subpopulation. Females with cubs-of-the-year and bears in dens are not protected by legislation in Quebec (because no provision was made for this in the *James Bay Agreement*), but there is local agreement among hunters not to kill these bears.

In Newfoundland and Labrador, Inuit have exclusive rights to harvest 6 bears/year (males and females without cubs) under a quota system along the Labrador coast (see Brazil and Goudie 2006). The killing of bears by anyone for any other purpose, other than defence of life and property, is prohibited. The polar bear is listed as Vulnerable under the *Newfoundland and Labrador Endangered Species Act.* This designation requires the development of a management plan (Brazil and Goudie 2006) and it allows for the development of additional regulations for the protection of polar bears, if deemed necessary for conservation purposes. It is planned that in the near future polar bear issues will be managed through the Torngat Wildlife and Plants Co-Management Board comprised of Inuit and federal and provincial government representatives. Management of polar bears in the Torngat Mountains National Park Reserve will be coordinated through a Co-operative Management Board as part of the *Labrador Inuit Park Impacts Agreement for the Torngat Mountains National Park Reserve.*

9.3 Risks from Lack of Protection/Trends in Current Management

Current Canadian and International programs of polar bear management—which primarily focus on harvest—raise a number of concerns for the future conservation of polar bears: 1) there has been a tendency for managers to focus on maximizing hunting opportunities through harvesting subpopulations at or close to the estimated maximum sustainable yield, and in some cases a lack of taking a precautionary approach to harvesting; 2) in some cases there is allowance for the hunting of polar bears without binding quotas to user groups; 3) existing agreements appear slow to respond to new population information, including instances of over harvest; 4) in most cases there remains a lack of co-management agreements for the conservation of shared subpopulations of polar bears; 5) effects of climate change on polar bears are not incorporated into any harvesting plans.

Routine management near what is believed to be the maximum sustainable yield (MSY) for some subpopulations presents a risk to polar bear conservation, especially in consideration of uncertainty in estimates of abundance, reproduction, and survival (Caughley 1977; Taylor *et al.* 2005, 2008d). For example, the Viscount Melville Sound (Section 7.4) and M'Clintock Channel (Section 7.7) subpopulations were both depleted by over-hunting when abundances and quotas were overestimated. Recovery of these subpopulations will take many years at reduced quotas (Taylor *et al.* 2002, 2008d). The estimated MSY for subpopulations of polar bears in Canada is annually computed by the PBTC. Estimates of MSY are based on a meta-analysis conducted in the 1990s that assumes the same reproduction and survival for polar bears across their range in Canada. This formula is $MSY = N \times 0.015/Pr[F]$, where N = total population number, 0.015 is a constant derived from a meta-analysis to estimate survival and recruitment rates for average Canadian polar bears, and Pr[F] = proportion of the harvest that is female (assumed to be 0.333, i.e., 2M:1F sex-selective harvest). Unfortunately, such deterministic estimates of MSY do not adequately reflect true risks of harvests to populations. For example, the current estimated maximum sustainable harvest for polar bears in Norwegian Bay is 9 bears/year (PBTC 2007). However, harvested-PVA that takes into account sampling error in initial subpopulation size, variance about vital rates due to sample size and annual environmental variation (survival, reproduction, sex ratio), and demographic stochasticity, suggests that even a quota of 4 bears/year may be unsustainable (Table 6).

Harvesting without quotas in subpopulations within or shared by Canada constitutes a threat to the conservation of polar bears. For example, the U.S. *Marine Mammal Protection Act* does not allow government restrictions on the annual number of polar bears killed by Alaskan Aboriginal hunters (Inupiat) for the Southern Beaufort Sea until the subpopulation, which is shared with Canada, has been depleted. In Canada, the harvest of polar bears by Inuit in Quebec is not limited by any quota or season restriction. Although lack of regulated quotas does not automatically mean that polar bears will be over-harvested, given the high demand for hunting opportunities the risk to subpopulations of polar bears from over-hunting where quotas do not uniformly limit harvest is readily apparent. Recent over-harvests in Kane Basin and Baffin Bay are testament to the dangers of hunting polar bears without all jurisdictions having quotas in a shared, co-management structure (Sections 7.12 and 7.13).

In Yukon, Northwest Territories, Nunavut, and Newfoundland and Labrador polar bears are managed under Aboriginal land claim management systems. These systems are relatively new and identify a detailed management process that includes consultations with affected hunters and their organizations and formal decisions from land claim Wildlife Boards (e.g., memoranda of understanding between parties). The consultation process can be lengthy and delay any management response, although this is likely to improve with time as these systems mature.

Co-management agreements between jurisdictions that share polar bears include an international agreement between the Inuvialuit and Inupiat for the Southern Beaufort Sea subpopulation (Section 7.2), and user-to-user agreements between the Inuvialuit and Kitikmeot Hunter's and Trappers Association (Regional Wildlife Organization) for the shared Northern Beaufort Sea and Viscount Melville Sound subpopulations. Inter-jurisdictional agreements are lacking for 6 subpopulations shared among user groups within Canada or internationally (i.e., Western Hudson Bay, Southern Hudson Bay, Foxe Basin, Davis Strait, Kane Basin, and Baffin Bay), and this may present a risk for polar bear conservation. For example, despite the regulated quotas in place for Baffin Bay by Nunavut and, since January, 2006, for Greenland, lack of a co-management agreement between these jurisdictions presently allows for a clearly unsustainable harvest of up to 190 bears (Table 6, Section 7.13; Taylor *et al.* 2005). Without a co-management agreement between Nunavut and Greenland, polar bears in Baffin Bay (and Kane Basin) are likely to continue to be over-harvested (Table 6, Sections 7.12 and 7.13)

Finally, no harvest programs currently accommodate anticipated changes in rates of survival and reproduction due to effects of climate change on the biology of polar bears, including reductions in food carrying capacity. In their recent review, Stirling and Parkinson (2006) suggest that a precautionary approach be taken to the harvesting of polar bears and that the potential effects of climate warming be incorporated into planning for management and conservation. Until research aimed at incorporating climate change into harvest models is carried out, it will be difficult to accurately predict sustainability of harvests. Sustainable hunting in the context of climate change will be essential to the conservation of the polar bear in Canada.

10. TECHNICAL SUMMARY

Ursus maritimus

Polar bear — Ours blanc

Inuktitut name: Nanuq, Nanuk — Cree name: Wapusk

Range of Occurrence in Canada: Yukon, Northwest Territories, Nunavut, Manitoba, Ontario, Quebec, Newfoundland and Labrador

Extent and Area Information

• *Extent of occurrence (EO)(km²)* See Sections 3.1 and 3.2	9.1×10^6 km^2
• *Specify trend in EO*	Stable
• *Are there extreme fluctuations in EO?*	No
• *Area of occupancy (AO) (km²)* See Sections 3.1 and 3.2	5.6×10^6 km^2
• *Specify trend in AO*	Stable
• *Are there extreme fluctuations in AO?*	No
• *Number of known or inferred current locations*	One
• *Specify trend in #*	Stable
• *Are there extreme fluctuations in number of locations?*	No
• *Specify trend in area, extent or quality of habitat*	Decline in quality where climate change is increasing the duration of the ice-free season.

Population Information

• *Generation time (average age of parents in the population)*	12 years
• *Number of mature individuals*	Total population 15,500; mature individuals >10,000
• *Total population trend:*	Decline
• *% decline over the last/next 10 years or 3 generations.*	Variable among subpopulations, overall likely less than 30%
• *Are there extreme fluctuations in number of mature individuals?*	No
• *Is the total population severely fragmented?*	No
• *Specify trend in number of populations*	n/a
• *Are there extreme fluctuations in number of populations?*	n/a
• *List populations with number of mature individuals in each:*	n/a

Threats (actual or imminent threats to populations or habitats)

Climate warming, over-harvest, pollution, increased offshore oil and gas development

Rescue Effect (immigration from an outside source)

• *Status of outside population(s)?* USA: Alaska, South Beaufort Sea (likely decline) Greenland: West Greenland (severe decline) Arctic Basin: Nomadic bears (unknown status)	
• *Is immigration known or possible?*	Yes
• *Would immigrants be adapted to survive in Canada?*	Yes
• *Is there sufficient habitat for immigrants in Canada?*	Yes
• *Is rescue from outside populations likely?*	No

Quantitative Analysis

See Section 7, Table 6

Current Status

COSEWIC: SPECIAL CONCERN, April, 2008 IUCN: VULNERABLE CITES: Appendix II US ESA: Threatened

Status and Reasons for Designation

Status: Special Concern	**Alpha-numeric code:** n/a
Reasons for Designation: The species is an apex predator adapted to hunting seals on the sea ice and is highly sensitive to over harvest. Although there are some genetic differences among bears from different parts of the Arctic, movement and genetic data support a single designatable unit in Canada. It is useful, however, to report trends by subpopulation because harvest rates, threats, and, hence, predicted population viability, vary substantially over the species' range. Some subpopulations are over harvested and current management mostly seeks the maximum sustainable harvest, which may cause declines if population monitoring is inadequate. Until 2006, some shared subpopulations were subject to harvest in Greenland that was not based on quotas. Population models project that 4 of 13 subpopulations (including approximately 28% of 15,500 polar bears in Canada) have a high risk of declining by 30% or more over the next 3 bear generations (36 years). Declines are partly attributed to climate change for Western Hudson Bay and Southern Beaufort Sea, but are mostly due to unsustainable harvest in Kane Basin and Baffin Bay. Seven subpopulations (about 43% of the total population) are projected to be stable or increasing. Trends currently cannot be projected for 2 subpopulations (29% of the total population). Bears in some subpopulations show declining body condition and changes in denning location linked to decreased availability of sea ice. For most subpopulations with repeated censuses, data suggest a slight increase in the last 10-25 years. All estimates of current population growth rates are based on currently available data and do not account for the possible effects of climate change. The species cannot persist without seasonal sea ice. Continuing decline in seasonal availability of sea ice makes it likely that a range contraction will occur in parts of the species range. Decreasing ice thickness in parts of the High Arctic may provide better habitat for the bears. Although there is uncertainty over the overall impact of climate change on the species' distribution and numbers, considerable concern exists over the future of this species in Canada.	

Applicability of Criteria

Criterion A (Declining Total Population): The Canadian population is now declining, but has increased over the past few decades. Four subpopulations (approximately 28% of 15,500 polar bears in Canada) have a high risk of declining by 30% or more over the next 3 bear generations. Seven subpopulations (about 43% of the total population) appear stable or increasing. Trends currently cannot be projected for 2 subpopulations (29% of the total population).
Criterion B (Small Distribution, and Decline or Fluctuation): The Area of Occupancy is over 5 million square kilometres.
Criterion C (Small Total Population Size and Decline): There are over 10,000 mature polar bears in Canada.
Criterion D (Very Small Population or Restricted Distribution): There are over 10,000 mature polar bears in Canada.
Criterion E (Quantitative Analysis): Trends assessed by management unit show that some subpopulations are declining whereas others are increasing. Overall trends are impossible to assess because trends differ by management unit, and not all units have adequate data. In addition, the expected negative effects of continuing global warming cannot be reliably assessed. Some declines are due to over harvest, and steps are being taken to reduce harvest in some management units. The best available data suggest that it is unlikely that the Canadian population of polar bears will decline by 30% over the next 36 years.

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13. BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Dr. Philip McLoughlin has been an active participant at meetings of the Federal/Provincial/Territorial Polar Bear Technical Committee (PBTC) for the past 4 years, and recently served as an invited specialist (Canadian delegation) for the 14th Working Group Meeting of the IUCN/SSC Polar Bear Specialist Group (June 20–24, 2005, Seattle, WA). Philip's main interest in polar bears lies in the analysis of mark-recapture data, population viability analysis, and the role of sex-biased harvesting in population management. Philip has published numerous papers on polar bears and grizzly bears in peer-reviewed journals.

Dr. Mitch Taylor has devoted the past 30 years of his life to the scientific study and management of polar bears in Canada. Mitch is author to over 40 peer-reviewed journal articles on the species, largely presenting results of his own field-based research program. Mitch is also an author of the 2002 COSEWIC update on the status of polar bears in Canada. Mitch is the Manager of the Wildlife Research Section of the Government of Nunavut's Department of Environment, and a long-term member of both the PBTC and IUCN/SSC Polar Bear Specialist Group.

Ms. Martha Dowsley is a Ph.D. candidate in the Department of Geography at McGill University under the supervision of Dr. George Wenzel. Her work examines the governance of common property resources, including polar bears. She is currently examining how Inuit perceptions of polar bears are changing. Her experience in the Arctic includes numerous community consultations with Inuit regarding concerns over polar bear population management, and possible effects of climate change on polar bears. Notably, she has conducted more than 70 interviews with elders and active hunters concerning polar bear management, harvesting, and cultural uses. Martha's research has also included an in-depth review of the Igloolik oral history archives on the traditional use of polar bears by Inuit.