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Polar Bears: Proceedings of the Fourteenth Working Meeting

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Polar Bears

Proceedings of the 14th Working Meeting of the IUCN/SSC Polar Bear Specialist Group, 20–24 June 2005, Seattle, Washington, USA

Compiled and edited by Jon Aars, Nicholas J. Lunn and Andrew E. Derocher

Occasional Paper of the IUCN Species Survival Commission No. 32

USGS science for a changing world
Nunavut
SSC Species Survival Commission

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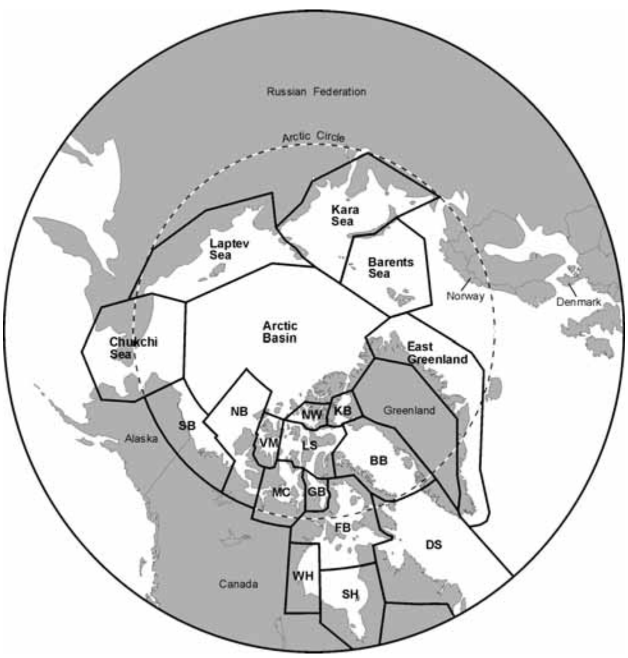
Status of the polar bear

Status and distribution

Polar bears are not evenly distributed throughout the Arctic, nor do they comprise a single nomadic cosmopolitan population, but rather occur in 19 relatively discrete subpopulations (Figure. 1). There is however an uncertainty about the discreteness of the less studied subpopulations, particularly in the Russian Arctic and neighbouring areas, due to very restricted data on live capture and tagging. The total number of polar bears worldwide is estimated to be 20,000–25,000. The following subpopulation summaries are the result of discussions of the IUCN/SSC Polar Bear Specialist Group held in Seattle, Washington, USA in June 2005 and updated with results that became available up to June 2006. The information on each subpopulation is based on the status reports and revisions given by each nation. We present estimated subpopulation sizes and associated uncertainty in estimates, historic and predicted human-caused mortality, and subpopulation trends, and rationale for our determinations of status. Where data allowed, or the approach was deemed appropriate for a jurisdiction, results of stochastic subpopulation viability analyses (PVA) to estimate the likelihood of future population decline are presented.

Figure 1. Distribution of polar bear populations throughout the circumpolar basin.



Status table structure

Subpopulation size

Table 1 presents subpopulation sizes and uncertainty in the estimates as ± 2 standard errors of the mean, 95% CI, or ranges. These estimates are based on scientific research using mark and recapture analysis or aerial surveys and the years in which data were collected are presented to give an indication of the current reliability of subpopulation estimates. For some subpopulations, scientific data were not available and population estimates were extrapolated from density estimates and/or local traditional ecological knowledge (TEK). In some cases, this also includes simulations based on the minimum size necessary to support local knowledge of subpopulation trends. Although these data are presented in addition to or in some cases as an alternative to dated scientific estimates, methods other than mark and recapture analysis or aerial surveys have unknown and in most cases inestimable errors.

Human-caused mortality

For most subpopulations, particularly those in North America, harvesting of polar bears is a regulated activity. In many cases, harvesting is the major cause of mortality for bears. In most jurisdictions, the total numbers of bears killed by humans in pursuit of sport and subsistence hunting, accident, and in defence of life or property are documented. Where data allow, we present the five-year mean of known human-caused mortality (removals) for each subpopulation. We also present the anticipated removal rate of polar bears in each jurisdiction based on known increases in hunting quotas and/or the average removal rate of polar bears by jurisdiction over the past five years.

Trend and status

Qualitative categories of trend and status are presented for each polar bear subpopulation (Table 1). Categories of trend include our assessment of whether the subpopulation is currently increasing, stable, or declining, or if we have insufficient data to estimate trend (data deficient). Categories of status include our assessment of whether subpopulations are not reduced, reduced, or severely reduced from historic levels of abundance, or if we have insufficient data to estimate status (data deficient).

Table 1. TR Status Report

	Aerial Survey/M-R Analysis		Additional/Alternative Analysis										
Sub-population	**Number (year of estimate)**	**estimate ±2 SE or 95% CI[1]**	**Number (year of estimate)**	**estimate ±2 SE[1] or min-max[2] range**	**Simulation**	**Density**	**TEK/IQ**	**Historical annual removals (5 yr mean)**	**Potential maximum annual removals**	**Observed or predicted trend**	**Status**	**Estimated risk of future decline (10 yrs)**	**Comments**
East Greenland	unknown							70	50	Data deficient	Data deficient	No Estimate	No subpopulation inventories have been conducted in East Greenland and therefore the size of the subpopulation is not known. During the last decades the extent of sea ice has decreased in the East Greenland area (e.g. Parkinson 2000). This decline is likely to continue (e.g. Rysgaard *et al.* 2003) resulting in a continued habitat destruction for polar bears in this area. Furthermore, various studies indicate that East Greenland polar bears may be negatively affected by relatively high body burden of organic pollutants (cf. Born and Sonne, this volume). During the last 5 years the total catch from the East Greenland subpopulation has decreased from 81 (1999) to 59 (2003) (Born and Sonne, this volume). Proposed quota (effective 1 Jan 2006) for East Greenland is 50 bears/year.
Barents Sea	2997 (2004)	2299 - 4116[1]						na		Data deficient	Data deficient	No Estimate	There has probably been an increase in the subpopulation size after 1973 until recently, but current subpopulation growth trend is unknown.
Kara Sea	unknown							na		Data deficient	Data deficient	No Estimate	The subpopulation size is unknown and no population surveys have been conducted in the Kara Sea.
Laptev Sea	800-1200 (1993)							na		Data deficient	Data deficient	No Estimate	The subpopulation size is based on Belikov (1993) using aerial counts of dens on the Severnaya Zemlya in 1982 and on anecdotal data collected in 1960-80s on the number of females coming to dens on Novosibirsk Islands and on mainland coast. The estimate should therefore be regarded as preliminary.
Chukchi Sea			2000 (1993)			X		43 - Alaska, unk. but substantial in Chukotka	uncertain	Data deficient	Data deficient	No Estimate	The subpopulation was estimated at 2000-5000 animals (Derocher *et al.* 1998) based on extrapolation of multiple years of spring den numbers data collected on Wrangel Island. The estimate was revised to 2000 animals with low confidence (Lunn *et al.* 2002). Abundance estimates with measurable levels of precision are not available. The subpopulation trend is believed to be declining and the status relative to historical levels is believed to be reduced based on harvest levels that were demonstrated to be unsustainable in the past. These harvest levels have been occurring for approximately the past 10–15 years. Without implementation of US-Russia polar bear treaty the levels of harvest are expected to continue and the risk for subpopulation depletion is rated as high.
Southern Beaufort Sea	1500 (2006)	1000 - 2000						58	81	Declining	Reduced	No Estimate	The 2006 subpopulation estimate is based on a preliminary analysis of capture-recapture data collected jointly by the U.S. and Canada, from 2001–2006. The 2006 subpopulation estimate was derived using the historic management boundaries for the SB subpopulation (i.e., from Icy Cape, Alaska, to Pierce Point, Northwest Territories, Canada). A final analysis of the recent capture-recapture data will be reported in 2007, along with suggestions for new management boundaries based on recent analyses of radiotelemetry data.
Northern Beaufort Sea	1200 (1986)	133 - 2097						36	65	Stable	Not reduced	No Estimate	A coordinated, intensive mark and recapture study covering the whole of the Beaufort Sea and Amundsen Gulf will be completed in 2006; a final analysis and report will follow.
Viscount Melville	161 (1992)	121 - 201	215 (1996)	99 - 331[1]	X			4	7	Increasing	Severely reduced	Very Low	14.0% of PVA simulation runs resulted in subpopulation decline after 10 years (86.0% resulted in subpopulation increase after 10 years). Simulations based on 1996 projected abundance.

* Where PVA simulations have been conducted, risk of decline is classed as Very Low (0–20%), Lower (20–40%), Moderate (40–60%), Higher (60–80%), and Very High (80–100%).

Table 1. TR Status Report (cont.)

	Aerial Survey/M-R Analysis		Additional/Alternative Analysis										
Sub-population	**Number (year of estimate)**	**estimate ±2 SE or 95% CI[1]**	**Number (year of estimate)**	**estimate ±2 SE[1] or min-max[2] range**	**Simulation**	**Density**	**TEK/IQ**	**Historical annual removals (5 yr mean)**	**Potential maximum annual removals**	**Observed or predicted trend**	**Status**	**Estimated risk of future decline (10 yrs)**	**Comments**
Norwegian Bay	190 (1998)	102 - 278						3	4	Declining	Not reduced	Higher	79.7% of PVA simulation runs resulted in population decline after 10 years (20.3% resulted in population increase after 10 years).
Lancaster Sound	2541 (1998)	1759 - 3323						74	85	Stable	Not reduced	Higher	78.3% of PVA simulation runs resulted in subpopulation decline after 10 years (21.7% resulted in subpopulation increase after 10 years). PVA estimate should be regarded as conservative due to unique male-bias in harvest (males decline over short term but not females); over longer time horizons PVA suggests sustainability of harvest.
M'Clintock Channel	284 (2000)	166 - 402						3	3	Increase	Severely reduced	Very Low	3.1% of PVA simulation runs resulted in subpopulation decline after 10 years (96.9% resulted in subpopulation increase after 10 years).
Gulf of Boothia	1523 (2000)	953 - 2093						46	74	Stable	Not reduced	Lower	21.0% of PVA simulation runs resulted in population decline after 10 years (79.0% resulted in population increase after 10 years).
Foxe Basin	2197 (1994)	1677 - 2717	2300 (2004)	1780 - 2820[1]	X		X	97	109	Stable	Not reduced	Lower	N = 2197, SE = 260 in 1994 based on Jolly-Seber M-R with tetracycline biomarking and harvest recoveries. Using Baffin Bay survival and recruitment rates, 25.9% of PVA simulation runs resulted in subpopulation decline after 10 years (74.1% resulted in subpopulation increase after 10 years).
Western Hudson Bay	935 (2004)	794 - 1076						45	64	Declining	Reduced	Very High	100.0% of PVA simulation runs resulted in subpopulation decline after 10 years (0.0% resulted in subpopulation increase after 10 years).
Southern Hudson Bay	1000 (1988)	684 - 1116						37	43	Stable	Not reduced	Lower	22.7% of PVA simulation runs resulted in population decline after 10 years (77.3% resulted in population increase after 10 years).
Kane Basin	164 (1998)	94 -234						11	15	Declining	Reduced	Very High	100.0% of PVA simulation runs resulted in subpopulation decline after 10 years (0.0% resulted in subpopulation increase after 10 years).
Baffin Bay	2074 (1998)	1544 - 2604	1546 (2004)	690 - 2402[1]	X			217	234	Declining	Reduced	Very High	100.0% of PVA simulation runs resulted in subpopulation decline after 10 years (0.0% resulted in subpopulation increase after 10 years).
Davis Strait			1650 (2004)	1000 - 2300[2]	X		X	65	74	Data deficient	Data deficient	Lower	The subpopulation was estimated at 1,400 in 1996 based on traditional ecological knowledge (TEK) that the subpopulation had increased with historical harvest levels; and simulation results suggesting that subpopulation could not have sustained the historical harvest at numbers less than 1,400. In 2004, the subpopulation estimate was increased to 1,650 based on TEK that the subpopulation had continued to increase; and simulations suggesting that an increase of about 250 (from 1,400 to 1,650) from 1996 was reasonable at post-1996 harvest levels. In 2005 a multi-year M-R survey was initiated to confirm subpopulation numbers and status. Using Baffin Bay survival and recruitment rates, and abundance as above, 23.4% of PVA simulation runs under projected harvest (potential maximum removals) resulted in subpopulation decline after 10 years (76.6% resulted in subpopulation increase after 10 years).
Arctic Basin	unknown							na					

* Where PVA simulations have been conducted, risk of decline is classed as Very Low (0–20%), Lower (20–40%), Moderate (40–60%), Higher (60–80%), and Very High (80–100%).

Subpopulation Viability Analysis

For some subpopulations, recent quantitative estimates of abundance and parameters of survival and reproduction are available to determine likelihoods of future subpopulation decline using stochastic subpopulation viability analysis (PVA). We used the PVA model RISKMAN (Taylor *et al.* 2001a) to estimate risks of future declines in polar bear subpopulations given demographic parameters and uncertainty in data. The model and documentation detailing the model's structure are available at www.nrdpfc.ca/riskman/riskman.htm. Publications based on the RISKMAN model include Eastridge and Clark (2001), McLoughlin *et al.* (2003), and Taylor *et al.* (2002).

RISKMAN can incorporate stochasticity into its subpopulation model 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 subpopulation size at a future time, subpopulation growth rate, and proportion of runs that result in a subpopulation decline set at a predetermined level by the user. We adopted the latter to estimate persistence probability.

Our approach to variance in this simulation was to pool sampling and environmental variances for survival and reproduction. We did this because: 1) variances for reproductive parameters often did not lend themselves to separating the sampling component of variance from environmental variance, and 2) we were interested in quantifying the risks of subpopulation decline including all sources of uncertainty in the data (i.e., pooling sampling error with environmental error presents more conservative outcomes of subpopulation persistence).

For each subpopulation model, the frequency of occurrence of subpopulation declines and/or increases after 10 years was reported as the cumulative proportion of total simulation runs (2,500 simulations). We chose to conduct model projections using these criteria because: 1) the subpopulation inventory cycle for most areas is planned to be 10–15 years in duration, and 2) we do not advocate using PVA over long time periods in view of potential significant changes to habitat resulting from arctic climate change. Individual runs could recover from 'depletion', but not from a condition where all males or all females or both were lost. Required subpopulation parameter estimates and standard error inputs included annual natural survival rate (stratified by age and sex as supported by the data), 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), litter size, the sex ratio of cubs, initial subpopulation size, and the sex, age, and family status distribution of the harvest. Input data may be found in Tables 1–3.

The standing age distribution was always female-biased, likely due to long-term harvesting of males in subpopulations for which simulations were performed (Table 1). 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. initializing the subpopulation at the stable age distribution produced more conservative outcomes compared to that of the existing standing age distribution). The harvest selectivity and vulnerability array was identified by comparing the standing age distribution of the historical harvest of subpopulations to the total mortality, stable age distribution. Harvest was stratified by sex, age (cubs and yearlings, age 2–5, age 6–19, and age >20) and family status (alone, or with cubs and yearlings, or with 2-year-olds). We ran harvest simulations using natural survival rates, upon which anticipated annual removal rates (i.e., human-caused mortality from all sources) were added.

East Greenland (EG)

No inventories have been conducted in recent years to determine the size of the polar bear subpopulation in eastern Greenland. Satellite-telemetry has indicated that polar bears range widely along the coast of eastern Greenland and in the pack ice in the Greenland Sea and Fram Strait (Born *et al.* 1997, Wiig *et al.* 2003). However, various studies have indicated that more or less resident groups of bears may occur within this range (Born 1995, Sandell *et al.* 2001). Although there is little evidence of a genetic difference between subpopulations in the eastern Greenland and Svalbard-Franz Josef Land regions (Paetkau *et al.* 1999), satellite telemetry and movement of marked animals indicate that the exchange between these subpopulations is minimal (Wiig 1995, Born *et al.* 1997, Wiig *et al.* 2003).

During 1999–2003 (last five years of recording), the annual catch in eastern and southwestern Greenland averaged 70 bears (range, 56–84 bears per year) (Born and Sonne, this volume). The catch of polar bears taken in southwestern Greenland, south of 62ºN, must be added to the catch statistics from eastern Greenland because polar bears arrive in the southwestern region

Table 2. Mean (and standard error [SE]) of natural (i.e., unharvested) survival parameters used in the assessment of risk for subpopulations listed in Table 1, and best estimates of parameters to model natural survival in FB, SH, WH, DS, NB, and SB. ***It is to these rates that anticipated annual removal rates are added for simulation.***

	Males Survival estimates of unharvested Bears				Females Survival estimates of unharvested Bears			
Subpopulation	**Cubs-of-the-year**	**1–4 yrs**	**5–20 yrs**	**>20 yrs**	**Cubs-of-the-year**	**1–4 yrs**	**5–20 yrs**	**>20 yrs**
BB	0.570 (0.094)	0.938 (0.045)	0.947 (0.022)	0.887 (0.060)	0.620 (0.095)	0.938 (0.042)	0.953 (0.020)	0.919 (0.050)
DS[1]	0.570 (0.094)	0.938 (0.045)	0.947 (0.022)	0.887 (0.060)	0.620 (0.095)	0.938 (0.042)	0.953 (0.020)	0.919 (0.050)
FB[2]	0.570 (0.094)	0.938 (0.045)	0.947 (0.022)	0.887 (0.060)	0.620 (0.095)	0.938 (0.042)	0.953 (0.020)	0.919 (0.050)
GB	0.817 (0.201)	0.907 (0.084)	0.959 (0.039)	0.959 (0.039)	0.817 (0.201)	0.907 (0.084)	0.959 (0.039)	0.959 (0.039)
KB	0.345 (0.200)	0.663 (0.197)	0.997 (0.026)	0.997 (0.026)	0.410 (0.200)	0.756 (0.159)	0.997 (0.026)	0.997 (0.026)
LS[3]	0.634 (0.123)	0.838 (0.075)	0.974 (0.030)	0.715 (0.095)	0.750 (0.104)	0.898 (0.005)	0.946 (0.018)	0.771 (0.054)
MC	0.619 (0.151)	0.983 (0.034)	0.921 (0.046)	0.921 (0.046)	0.619 (0.151)	0.983 (0.034)	0.977 (0.033)	0.977 (0.033)
NW[3]	0.634 (0.123)	0.838 (0.075)	0.974 (0.030)	0.715 (0.095)	0.750 (0.104)	0.898 (0.005)	0.946 (0.018)	0.771 (0.054)
SH[2]	0.570 (0.094)	0.938 (0.045)	0.947 (0.022)	0.887 (0.060)	0.620 (0.095)	0.938 (0.042)	0.953 (0.020)	0.919 (0.050)
VM	0.448 (0.216)	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)
WH[4]	0.500 (0.033)	0.870 (0.026)	0.940 (0.010)	0.780 (0.023)	0.610 (0.028)	0.920 (0.020)	0.940 (0.008)	0.810 (0.020)

[1] Incorporates 1993–1998 BB data (Taylor *et al.* 2005).
[2] Incorporates 1993–1998 BB data (Taylor *et al.* 2005).
[3] Survival estimates pooled for LS and NW (see text for LS and NW).
[4] Based on vital rates provided by E. Regehr (USGS, Alaska Science Center, Anchorage, AK). Survival rates for WH were estimated using an age structure that differs slightly from Table 2. The "Cubs-of-the-year" survival rate in Table 2 applies to WH juvenile polar bears (age 0–1 yr); the "1–4 yrs" survival rate in Table 2 applies to WH subadult polar bears (age 2–4 yrs). Standard errors represent estimated sampling variance only.

Table 3. Mean (and standard error [SE]) of reproductive parameters (standing age capture data) used in the assessment of risk for populations listed in Table 1, and best estimates of parameters to model FB, SH, WH, DS, NB, and SB.

		Litter-production rate				
Subpopulation	**Litter size**	**4-year-olds**	**5-year-olds**	**6-year-olds**	**>6-year-olds**	**Proportion male cubs**
BB	1.587 (0.073)	0.096 (0.120)	0.881 (0.398)	1.000 (0.167)	1.000 (0.167)	0.493 (0.029)
DS[1,2]	1.587 (0.073)	0.096 (0.120)	0.881 (0.398)	1.000 (0.167)	1.000 (0.167)	0.493 (0.029)
FB[1]	1.587 (0.073)	0.096 (0.120)	0.881 (0.398)	1.000 (0.167)	1.000 (0.167)	0.493 (0.029)
GB	1.648 (0.098)	0.000 (0.000)	0.194 (0.178)	0.467 (0.168)	0.965 (0.300)	0.460 (0.091)
KB	1.667 (0.083)	0.000 (0.000)	0.000 (0.000)	0.357 (0.731)	0.478 (0.085)	0.426 (0.029)
LS	1.688 (0.012)	0.000 (0.000)	0.107 (0.050)	0.312 (0.210)	0.954 (0.083)	0.531 (0.048)
MC	1.680 (0.147)	0.000 (0.000)	0.111 (0.101)	0.191 (0.289)	0.604 (0.928)	0.545 (0.057)
NW	1.714 (0.081)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.689 (0.534)	0.544 (0.066)
SH[2]	1.575 (0.116)	0.087 (0.202)	0.966 (0.821)	0.967 (0.022)	0.967 (0.022)	0.467 (0.086)
VM	1.640 (0.125)	0.000 (0.000)	0.623 (0.414)	0.872 (0.712)	0.872 (0.712)	0.535 (0.118)
WH[2]	1.540 (0.110)	0.000 (0.000)	0.257 (0.442)	0.790 (0.180)	0.790 (0.180)	0.480 (0.110)

[1] Reproductive estimates from BB (Taylor *et al.* 2005).
[2] Best estimates for modelling exercise only (from standing age capture data).

with the drift ice that comes around the southern tip from eastern Greenland (Sandell *et al.* 2001). During 1993 (first year of instituting a new catch recording system) and 2003 there was no significant trend in the catch of polar bears in eastern and southwestern Greenland (Born and Sonne, this volume).

Despite an increasing practice by hunters from Scoresby Sound in Central East Greenland to go further north to take polar bears during spring, there is no information to indicate an overall increase in hunting by East Greenlanders (Sandell *et al.* 2001). Based on harvest sampling from 109 polar bears in Scoresby Sound during 1999–2001 (Danish National Environmental Research Institute, unpubl. data), the proportion of adult (=independent) female polar bears in the catch in eastern Greenland is estimated at 0.43.

Given the estimates of the proportion of adult females in the catch and an annual catch of about 70 bears (*i.e.*, eastern and southwestern Greenland combined), a minimum subpopulation of about 2000 individuals would be needed to sustain this take. However, the actual number of animals in the exploited subpopulation is unknown.

During the last decades, the ice in the East Greenland area has diminished both in extent and thickness (*e.g.* Parkinson 2000). It has been predicted that this trend will continue in this century (Rysgaard *et al.* 2003). Furthermore, polar bears in East Greenland have relatively high body burdens of organic pollutants (Norstrom *et al.* 1998, Dietz *et al.* 2004) and levels of these pollutants seem to have increased between 1990 and 1999–2001 (Dietz *et al.* 2004). Several studies indicate that organic pollutants may have negatively affected polar bears in this region (overview in Born and Sonne, this volume).

The effects of arctic warming on East Greenland polar bears have not been documented. However, considering the effects of climate change in other parts of the Arctic (e.g. western Hudson Bay), these environmental changes cause concern about how polar bears in East Greenland may be negatively affected.

Barents Sea (BS)

The size of the Barents Sea subpopulation was estimated to be about 3000 in August 2004 (see section "Line transect estimate of the subpopulation size of polar bears in the Barents Sea"*,* this volume). This suggests that earlier estimates based on den counts and ship surveys (Larsen 1986) were too high. This suggestion is further supported by ecological data that indicate the subpopulation grew steadily the first decade after protection from hunting in 1973, and then either continued to grow or flattened out after that. Denning occurs on several islands both on Franz Josef Land (Belikov and Matveev 1983) and Svalbard (Larsen 1985). Studies on individual movement and subpopulation ecology by use of telemetry data and mark-recapture have been conducted in the Svalbard area since the early 1970s (Larsen 1972, 1986, Wiig 1995, Mauritzen *et al.* 2001, 2002). Studies on movements using telemetry data show that some polar bears associated with Svalbard are very restricted in their movements but bears from the Barents Sea range widely between Svalbard and Franz Josef Land (Wiig 1995, Mauritzen *et al.* 2001). Subpopulation boundaries based on satellite telemetry data indicate that the Barents Sea has a natural subpopulation unit, albeit with some overlap to the east with the Kara sea subpopulation (Mauritzen *et al.* 2002). Although overlap between the Barents Sea and East Greenland may be limited (Born *et al.* 1997), low levels of genetic structure among all these subpopulations indicates substantial gene flow (Paetkau *et al.* 1999). The Barents Sea subpopulation is currently unharvested with the exception of bears killed in defence of life and property (Gjertz and Persen 1987, Gjertz *et al.* 1993, Gjertz and Scheie 1997). The subpopulation was depleted by over-harvest but a total ban on hunting in 1973 in Norway and in 1956 in Russia allowed the subpopulation to increase (Larsen 1986, Prestrud and Stirling 1994). High levels of PCBs have been detected in samples of polar bears from this area which raises concern about the effects of pollutants on polar bear survival and reproduction (Skaare *et al.* 1994, Bernhoft *et al.* 1997, Norstrom *et al.* 1998, Andersen *et al.* 2001, Derocher *et al.* 2003). Recent studies suggest a decline and levelling of some pollutants (Henriksen *et al.* 2001) while new pollutants have been discovered (Wolkers *et al.* 2004). Oil exploration in polar bear habitat may increase in the near future (Isaksen *et al.* 1998). The natural history of this subpopulation is well known (Lønø 1970, Derocher 2005).

Kara Sea (KS)

This subpopulation includes the Kara Sea and overlaps in the west with the Barents Sea subpopulation in the area of Franz Josef Land and Novaya Zemlya archipelagos. Data for the Kara and Barents Seas, in the vicinity of Franz Josef Land and Novaya Zemlya, are mainly based on aerial surveys and den counts (Parovshikov 1965, Belikov and Matveev 1983, Uspenski 1989, Belikov *et al.* 1991, Belikov and Gorbunov 1991, Belikov 1993). Telemetry studies of movements have been done throughout the area but data to define the eastern boundary are incomplete (Belikov *et al.* 1998, Mauritzen *et al.* 2002). The subpopulation estimate should be regarded as preliminary. Reported harvest activities have been limited to defence kills and an unknown number of illegal kills and these are not thought to be having an impact on the size of the subpopulation. However, contaminant levels in rivers flowing into this area and recent information on nuclear and industrial waste disposal raise concerns about the possibility of environmental damage. Recent studies clearly show that polar bears from the Kara Sea have some of the highest organochlorine pollution levels in the Arctic (Andersen *et al.* 2001, Lie *et al.* 2003).

Laptev Sea (LS)

The Laptev subpopulation area includes the western half of the East Siberian Sea and most of the Laptev Sea, including the Novosibirsk and possibly Severnaya Zemlya islands (Belikov *et al.* 1998). The estimate of subpopulation size for the Laptev Sea (800–1,200) is based on aerial counts of dens on the Severnaya Zemlya in 1982 (Belikov and Randla 1987) and on anecdotal data collected in 1960–80s on the number of females coming to dens on Novosibirsk Islands and on mainland coast (Kischinski 1969, Uspenski 1989). This estimate should therefore be regarded as preliminary. Reported harvest activities in this subpopulation are limited to defence kills and an apparently small but unknown number of illegal kills. The current levels of harvest are not thought to be having a detrimental impact on the subpopulation.

Chukchi Sea (CS)

Cooperative studies between the USA and Russia have revealed that polar bears in this area, also known as the Alaska-Chukotka subpopulation, are widely distributed on the pack ice of the northern Bering, Chukchi, and eastern portions of the East Siberian seas (Garner *et al.* 1990, 1994, 1995). Based upon these early telemetry studies, the western boundary of the subpopulation was set near Chaunskaya Bay in northeastern Russia. The eastern boundary was set at Icy Cape, Alaska, which is also the previous western boundary of the Southern Beaufort Sea subpopulation (Amstrup *et al.* 1986, Amstrup and DeMaster 1988, Garner *et al.* 1990, Amstrup *et al.* 1995, 2004, 2005). This eastern boundary constitutes a large overlap zone with bears in the SB subpopulation.

Estimates of the size of the subpopulation have been derived from observations of dens, and aerial surveys (Chelintsev 1977, Stishov 1991a,b, Stishov *et al.* 1991). However, these estimates have wide ranges and are considered to be of little value for management. Reliable estimates of subpopulation size based upon mark and recapture have not been available for this region although recent studies provide data for analyses using new spatial modelling techniques as reported in the southern Beaufort Sea subpopulation section. Probabilistic distribution information for zones of overlap between the Chukchi and Southern Beaufort Sea subpopulations is now available. This information can be used to more accurately describe sustainable harvest levels once defensible estimates of abundance are developed (Amstrup *et al.* 2004, 2005). The approximate boundaries of this subpopulation for illustration purposes are as described above and as reported previously (Lunn *et al.* 2002).

The status of the Chukchi subpopulation, which was believed to have increased after the level of harvest was reduced in 1972, is now thought to be uncertain or declining. The absolute numbers of animals in the subpopulation remain a research challenge and recent reports of substantial levels of illegal harvest in Russia are cause for concern. Legal harvesting activities are currently restricted to Inuit in Western Alaska. In Alaska, average annual harvest levels declined by approximately 50% between the 1980s and the 1990s (Schliebe *et al.* 1998) and remain depressed today. There are several factors potentially affecting the harvest level in western Alaska. The factor of greatest direct relevance is the substantial illegal harvest in Chukotka. In addition, other factors such as climatic change and its effects on pack ice distribution as well as changing demographics and hunting effort in native communities (Schliebe *et al.* 2002) could have influencing the declining take. Recent measures undertaken by regional authorities in Chukotka may have reduced the illegal hunt. The unknown rate of illegal take makes the stable designation uncertain and tentative and as a precaution the Chukchi subpopulation is designated as declining.

Implementation of the Russia-United States Agreement on the Conservation and Management of polar bear is designed to ensure a scientifically-based sustainable management programme is instituted. Management will include active involvement of Native hunters' organizations from Alaska and Chukotka.

As with the Beaufort Sea subpopulation, the primary concerns for this region are the impacts of climate change, human activities including industrial development within the near-shore environment, increases in the atmospheric and oceanic transport of contaminants into the region, and possible over-harvest of a stressed or declining subpopulation.

Southern Beaufort Sea (SB)

The Southern Beaufort Sea (SB) polar bear subpopulation is shared between Canada and Alaska. During the early 1980s, radio-collared polar bears were followed from the Canadian Beaufort Sea into the eastern Chukchi Sea of Alaska (Amstrup *et al.* 1986, Amstrup and DeMaster 1988). Radio-telemetry data, combined with earlier tag returns from harvested bears, suggested that the SB region comprised a single subpopulation with a western boundary near Icy Cape, Alaska, and an eastern boundary near Pearce Point, Northwest Territories, Canada (Amstrup *et al.* 1986, Amstrup and DeMaster 1988, Stirling *et al.* 1988). Recognition that the polar bears within this region were shared by Canada and Alaska prompted development of the "Polar Bear Management Agreement for the Southern Beaufort Sea" (Agreement) between the Inuvialuit Game Council (IGC) of Canada, and the North Slope Borough (NSB) of Alaska. The Agreement was ratified by both parties in 1988. The text of the Agreement included provisions to protect bears in dens and females with cubs, and stated that the annual sustainable harvest from the SB polar bear subpopulation would be shared between the two jurisdictions. Harvest levels also were to be reviewed annually in light of the best scientific information available (Treseder and Carpenter 1989, Nageak *et al.* 1991). An evaluation of the effectiveness of the Agreement during the first 10 years (Brower *et al.* 2002) concluded that the Agreement had been successful in ensuring that the total harvest, and the proportion of the harvest comprised of adult females, remained within sustainable limits. The evaluation also noted that increased monitoring efforts and continued restraint in harvesting females were necessary to ensure continued compliance with the provisions of the Agreement.

Early estimates suggested the size of the SB subpopulation was approximately 1,800 polar bears, although uneven sampling was known to compromise the accuracy of that estimate (Amstrup *et al.* 1986, Amstrup and DeMaster 1988, Amstrup 1995). New population estimation techniques are emerging and continue to be refined (Amstrup *et al.* 2001, 2005; McDonald and Amstrup 2001). The field work for an intensive capture-recapture effort in the SB region, coordinated between the U.S. and Canada, was conducted between spring 2001 and spring 2006. Analysis of the joint data collected between 2001 and 2006 was completed in September 2006. That analysis produced a population estimate for the region between Icy Cape and Pearce Point of 1,526 polar bears (95% confidence interval: 1,211, 1,841). Although the point estimates (1,800 previously and 1,525 now) suggest a decline in numbers, the overlap of the current confidence interval with the previous point estimate prohibits an unequivocal statistical conclusion that the sub-population has declined. Whereas we cannot draw a purely statistical conclusion that the sub-population level has declined; declines in cub survival, and other ecological evidence are consistent with a changing sub-population status. Also, observations of changes in polar bear body condition and unusual hunting behaviours in polar bears (e.g. cannibalism, digging through solid ice to find seals) suggest a sub-population that may be under nutritional stress (Amstrup *et al.* 2006, Stirling unpublished observations). These observations parallel those made in western Hudson Bay (see below), where changes in sea ice, caused by warmer temperatures, have caused sub-population reductions. These observations, therefore, mandate increased vigilance in the southern Beaufort Sea region.

Stirling (2002) reviewed the ecology of polar bears and seals in the Canadian sector of the Beaufort Sea from 1970 through 2000. Research incorporating the collection and analysis of radio-telemetry data in the SB region has continued on a nearly annual basis through the present time. Recent analyses of radio-telemetry data using new spatial modelling techniques suggest realignment of the boundaries of the SB area (Amstrup *et al.* 2004, 2005). We now know that nearly all bears in the central coastal region of the Beaufort Sea are from the SB subpopulation, and that proportional representation of SB bears decreases to both the west and east. For example only 50% of the bears occurring in Barrow (Alaska) and Tuktoyaktuk (Northwest Territories) are SB bears, with the remainder being from the Chukchi (CS) and northern Beaufort Sea (NB) subpopulations, respectively. The recent radio-telemetry data indicate that bears from the SB subpopulation seldom reach Pearce Point, which is currently on the eastern management boundary for the SB subpopulation.

Historically, a principal assumption of the IGC/NSB Agreement was that polar bears harvested within the SB region came from a single subpopulation. However, our improved understanding of the spatiotemporal use patterns of bears in the SB region provides the foundation for improved harvest management, based on the geographic probability of bears occurring in specific areas at specific times of the year (Amstrup *et al.* 2005). Assignment of new boundaries based upon this information will probably necessitate a readjustment of the total size of the SB subpopulation, to correspond with a smaller geographic area. This adjustment is likely to reduce the estimated size of the SB subpopulation because some polar bears formerly assigned to the SB will be re-assigned to the NB and CS subpopulations. However, for purposes of this report we continue to use the previously-published boundaries for the SB subpopulation. This subpopulation is assessed using the sustainable yield criteria previously reported.

The primary management and conservation concerns for the SB subpopulation are: 1) climate warming, which continues to increase both the expanse and duration of open water in summer and fall; 2) human activities, including hydrocarbon exploration and development occurring within the near-shore environment; 3) changing atmospheric and oceanic transport of contaminants into the region; and 4) possible inadvertent over-harvest of the SB subpopulation, if it becomes increasingly nutritionally-stressed or declines due to some combination of the aforementioned threats.

Northern Beaufort Sea (NB)

Studies of movements and subpopulation estimates of polar bears in the eastern Beaufort Sea have been conducted using telemetry and mark-recapture at intervals since the early 1970s (Stirling *et al.* 1975, 1988, DeMaster *et al.* 1980, Lunn *et al.* 1995). As a result, it was recognized that there were separate subpopulations in the North and South Beaufort Sea areas and not a single subpopulation as was suspected initially (Stirling *et al.* 1988, Amstrup 1995, Taylor and Lee 1995, Bethke *et al.* 1996). The density of polar bears using the multi-year ice north of the main study area was lower than it was further south. The subpopulation estimate of 1,200 polar bears (Stirling *et al.* 1988) for the North Beaufort Sea (NB) was believed to be unbiased at the time but the northwestern coast of Banks Island was not completely surveyed because of perceived conflicts with guided sport hunters in the area at that time. A coordinated, intensive mark and recapture study covering the whole of the Beaufort Sea and Amundsen Gulf will be completed in 2006; a final analysis and report will follow. Until this new estimate is available, the previous estimate and quota will continue to be used for management purposes. The harvest is being closely monitored and appears to be sustainable.

Recent analyses, using data from satellite tracking of female polar bears and new spatial modelling techniques, indicate the boundary between NB and the southern Beaufort Sea (SB) subpopulations needs to be adjusted, probably expanding the area occupied by bears from NB and retracting that of SB (Amstrup *et al.* 2004, 2005).

The primary concerns for this subpopulation are from climate warming that continues to expand both the expanse and duration of open water in summer and fall, changing characteristics of atmospheric and oceanic transport of contaminants into the region, and possible inadvertent over-harvest of a subpopulation stressed or declining as a result of the previous threats.

Viscount Melville Sound (VM)

A five-year study of movements and size of the Viscount Melville Sound (VM) subpopulation, using telemetry and mark-recapture, was completed in 1992 (Messier *et al.* 1992, 1994, Taylor *et al.* 2002). Subpopulation boundaries are based on observed movements of female polar bears with satellite radio-collars and movements of bears tagged in and out of the study area (Bethke *et al.* 1996, Taylor *et al.* 2001*b*). The current subpopulation estimate of 215 (SE = 58) was based on estimates time referenced to 1993 (Taylor *et al.* 2002). When quotas were originally allocated in the 1970s, the size and productivity of the subpopulation was thought to be greater because they occurred in such a large geographic area. However, this area is characterized by heavy multi-year ice and low densities of ringed seals (Kingsley *et al.* 1985), and the productivity and density of polar bears was lower than initially expected. Consequently, quotas were reduced and a five-year moratorium on hunting began in 1994/95. Hunting resumed in 1999/2000 with an annual quota of four bears.

In 1999, the former Northwest Territories (NWT) was divided into two new territories: NWT and Nunavut and resulted in the VM subpopulation being shared between the two jurisdictions. In 2004/2005 the annual quota was increased to seven bears (NWT – four, Nunavut – three).

Norwegian Bay (NW)

The Norwegian Bay (NW) polar bear subpopulation is bounded by heavy multi-year ice to the west, islands to the north, east, and west, and polynyas to the south (Stirling 1980, 1997, Taylor *et al.* 2001b, unpubl. data). From data collected during mark-recapture studies, and from satellite radio-tracking of adult female polar bears, it appears that most of the polar bears in this subpopulation are concentrated along the coastal tide cracks and ridges along the north, east, and southern boundaries (Taylor *et al.* 2001b). The preponderance of heavy multi-year ice through most of the central and western areas has resulted in low densities of ringed seals (Kingsley *et al.* 1985) and, consequently, low densities of polar bears. Based on preliminary data, the current (1993–97) estimate for this subpopulation is 190 bears (SE = 48.1) (M.K. Taylor *et al.*, unpubl. data). Survival rate estimates for the NW subpopulation were derived from pooled Lancaster Sound and NW data because the subpopulations are adjacent and because the number of bears captured in Lancaster Sound was too small for reliable survival estimates. Recruitment estimates were derived from the standing age distribution (Taylor *et al.* 2000). The harvest quota for the NW subpopulation was reduced to four bears (three males and one female) in 1996.

Lancaster Sound (LS)

The central and western portion of the Lancaster Sound (LS) subpopulation region is characterized by high biological productivity and high densities of ringed seals and polar bears (Schweinsburg *et al.* 1982, Stirling *et al.* 1984, Kingsley *et al.* 1985, Welch *et al.* 1992). The western third of this region (eastern Viscount Melville Sound) is dominated by heavy, multi-year ice and apparently low biological productivity, as evidenced by 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. Recent information on the movements of adult female polar bears monitored by satellite radio-collars, and mark-recapture data from past years, has shown that this subpopulation is distinct from the adjoining Viscount Melville Sound, M'Clintock Channel, Gulf of Boothia, Baffin Bay and Norwegian Bay subpopulations (Taylor *et al.* 2001b). For PVA in this status report, survival rates of polar bears in the Norwegian Bay and Lancaster Sound subpopulations were pooled to minimize sampling errors. The current subpopulation estimate of 2,541 bears (SE = 391) is based on an analysis of both historical and current mark-recapture data to 1997 (M.K. Taylor *et al.*, unpubl. data). This estimate is considerably larger than a previous estimate of 1,675 that included Norwegian Bay (Stirling *et al.* 1984), and was considered to be conservative. Taylor *et al.* (unpubl. data) also estimate a suite of survival and recruitment parameters (Table 2) that suggest this subpopulation has a lower renewal rate than previously estimated.

M'Clintock Channel (MC)

The current subpopulation boundaries for the M'Clintock Channel (MC) subpopulation of polar bears are based on recovery of tagged bears and movements of adult females with satellite radio-collars in adjacent areas (Taylor and Lee 1995, Taylor *et al.* 2001*b*). These boundaries appear to be a consequence of large islands to the east and west, the mainland to the south, and the heavy multi-year ice in Viscount Melville Sound to the north. A six-year mark-recapture study covered most of this area in the mid-1970s (Furnell and Schweinsburg 1984). An estimate of 900 bears was derived from the data collected within the boundaries proposed for the M'Clintock Channel subpopulation, as part of a study conducted over a larger area of the Central Arctic (Furnell and Schweinsburg 1984). More recently, local hunters suggested 900 might be too high, so the Canadian Polar Bear Technical Committee accepted a recommendation to reduce the estimate to 700.

Following the completion of a mark-recapture inventory in spring 2000, the subpopulation was estimated to number 284 (SE = 59.3) (Taylor *et al.* in review). Natural survival and recruitment rates (Table 2) were also estimated at values lower than previous standardized estimates (Taylor *et al.* 1987). The Government of Nunavut implemented a moratorium on hunting for the 2001/2002 and 2002/2003 hunting seasons. The current annual quota for MC is three bears.

Gulf of Boothia (GB)

The subpopulation boundaries of the Gulf of Boothia (GB) polar bear subpopulation are based on genetic studies (Paetkau *et al.* 1999), movements of tagged bears (Stirling *et al.* 1978, Taylor and Lee 1995), movements of adult females with satellite radio-collars in GB and adjacent areas (Taylor *et al.* 2001b), and interpretations by local Inuit hunters of how local conditions influence the movements of polar bears in the area. An initial subpopulation estimate of 333 bears was derived from data collected as part of a study conducted over a larger area of the Central Arctic (Furnell and Schweinsburg 1984). Although subpopulation data from GB were limited, local hunters reported that the subpopulation was stable or had increased since the time of the Central Arctic Polar Bear survey. Based on Inuit knowledge, recognition of sampling deficiencies, and polar bear densities in other areas, in the 1990s an interim subpopulation estimate of 900 for GB was established.

Following the completion of a mark-recapture inventory in spring 2000, the subpopulation was estimated to number 1,523 bears (SE = 285) (M.K. Taylor *et al.*, unpubl. data). Natural survival and recruitment rates (Table 2) were estimated at values higher than the previous standardized estimates (Taylor *et al.* 1987).

Foxe Basin (FB)

Based on 12 years of mark-recapture studies, tracking of female bears with conventional radios, and satellite tracking of adult females in western Hudson Bay and southern Hudson Bay, the Foxe Basin (FB) subpopulation of polar bears appears to occur in Foxe Basin, northern Hudson Bay, and the western end of Hudson Strait (Taylor and Lee 1995). During the ice-free season, polar bears are concentrated on Southampton

Island and along the Wager Bay coast; however, significant numbers of bears are also encountered on the islands and coastal regions throughout the Foxe Basin area. A total subpopulation estimate of 2,119 bears (SE = 349) was developed in 1996 (M.K. Taylor, unpubl. data) from a mark-recapture analysis based on tetracycline biomarkers (Taylor and Lee 1994). The marking effort was conducted during the ice-free season, and distributed throughout the entire area. The subpopulation estimate is believed to be accurate, but dated. Simulation studies suggest that the previous harvest quotas prior to 1996 reduced the subpopulation from about 3,000 bears in the early 1970s to about 2,100 bears in 1996. Harvest levels were reduced in 1996 to permit slow recovery of this subpopulation, provided that the kill in Québec did not increase.

In December 2004, TEK indicated that the subpopulation had increased. After consultations with native communities, Nunavut increased the harvest quota to a level consistent with a subpopulation level of 2,300 bears. Co-management discussions with Québec are ongoing. Survival and recruitment rates used for risk assessment are based on the detailed rates obtained for the adjacent Baffin Bay subpopulation (Taylor *et al.* 2005).

Western Hudson Bay (WH)

The distribution, abundance, and population boundaries of the Western Hudson Bay (WH) polar bear subpopulation have been the subject of research programmes since the late 1960s (Stirling *et al.* 1977, 1999, Derocher and Stirling 1995a,b, Taylor and Lee 1995, Lunn *et al.* 1997). Over 80% of the adult subpopulation is marked, and there are extensive records from capture-recapture studies and tag returns from polar bears killed by Inuit hunters. During the open water season, the WH subpopulation appears to be geographically segregated from the Southern Hudson Bay subpopulation to the east and the Foxe Basin subpopulation to the north. During the winter and spring, the three subpopulations mix extensively on the sea ice covering Hudson Bay (Stirling *et al.* 1977, Derocher and Stirling 1990, Stirling and Derocher 1993, Taylor and Lee 1995). The size of the WH subpopulation was estimated to be 1,200 bears in autumn, in 1988 and 1995 (Derocher and Stirling 1995*a*, Lunn *et al.* 1997). At that time, the size of the WH subpopulation appeared to be stable, and the harvest was believed to be sustainable.

Over the past three decades, there have been significant declines in the body condition of adult male and female polar bears, and in the proportion of independent yearlings captured during the open water season in western Hudson Bay (Derocher and Stirling 1992, 1995b, Stirling and Lunn 1997, Stirling *et al.* 1999, N. Lunn and I. Stirling, unpubl. data). Over the same period, the average date of spring break-up of the sea ice in the region has advanced by three weeks (Stirling *et al.* 1999, 2004), presumably due to increasing spring air temperatures. Warming rates in western Hudson Bay between 1971 and 2001 ranged from a minimum 0.5°C per decade at Churchill, Manitoba, to 0.8°C per decade at Chesterfield Inlet, Nunavut (Gagnon and Gough 2005). Stirling *et al.* (1999) documented a significant correlation between the timing of sea ice break-up and the body condition of adult female polar bears (i.e., early break-up was associated with poor body condition). Stirling *et al.* (1999) also suggested that the declines in various life history parameters of polar bears in western Hudson Bay were the result of nutritional stress associated with the trend toward earlier break-up, which in turn appears to be due to long-term warming.

An updated analysis of capture-recapture data from the WH subpopulation was completed in 2005 (E. Regehr *et al.*, U.S. Geological Survey, in review). Between 1987 and 2004, the number of polar bears in the WH subpopulation declined from 1,194 (95% CI = 1020, 1368) to 935 (95% CI = 794, 1076), a reduction of about 22%. This decline appears to have been initiated by progressive declines in the body condition and survival of cubs, subadults, and bears 20 years of age and older, caused by the earlier break-up of spring sea ice as a result of climate warming. Once the subpopulation began to decline because of changing environmental conditions, the existing harvest was no longer sustainable, and the additive effects of climate change and over-harvest most likely accelerated the decline in subpopulation size between 1987 and 2004. The harvest sex ratio of two males per female has resulted in a skewed sex ratio within the subpopulation of 65% female and 35% male polar bears (E. Regehr *et al.*, U.S. Geological Survey, unpubl. data).

Concurrent with the recent re-assessment of the size of the WH subpopulation, an increased number of polar bears have been reported in and around human settlements along the coast of western Hudson Bay. In some communities, this increase in polar bear sightings has been interpreted as evidence that the size of the WH subpopulation is increasing. Based on this perception, the government of Nunavut in December 2004 increased its quota for the number of polar bears that could be harvested from the WH subpopulation from 55 to 64 polar bears. In order to sustain this increased level of harvest, Nunavut estimated that the size of the WH subpopulation would have to be at least 1,400 bears; this is the subpopulation estimate currently used by Nunavut for management purposes. An alternate explanation for the apparent increase in polar bears in the vicinity of human settlements and hunting camps is that, because of declines in body condition associated with the earlier sea ice break-up, polar bears in western Hudson Bay have less time to accumulate the fat reserves that they depend on during the open water season. As polar bears deplete their fat reserves toward the end of the open water season, they are more likely to seek alternative food sources around human settlements to sustain themselves until freeze-up.

Southern Hudson Bay (SH)

Boundaries of the Southern Hudson Bay (SH) polar bear subpopulation are based on movements of marked bears and telemetry studies (Jonkel *et al.* 1976, Kolenosky and Prevett 1983, Kolenosky *et al.* 1992, Taylor and Lee 1995). Recently completed research using satellite radio-collared bears was aimed at refining the boundaries of this subpopulation (M. Obbard, M.K. Taylor, and F. Messier, unpubl. data) and estimating the subpopulation size and rates of birth and death (M. Obbard, unpubl. data). The current estimate of the size of the subpopulation comes from a three-year (1984–1986) mark-recapture study, conducted mainly along the Ontario coastline (Kolenosky *et al.* 1992). This study and the more recent telemetry data have documented seasonal fidelity to the Ontario coast during the ice-free season, and some intermixing with the Western Hudson Bay and Foxe Basin subpopulations during months when the bay is frozen over. In 1988, the results of a modelling workshop included an increase in the subpopulation estimate from 900 to 1,000 bears because portions of the eastern and western coastal areas were not included during original sampling. Additionally, the area away from the coast may have been under-sampled due to difficulties in locating polar bears inland (i.e., below the tree line). Thus, some classes of bears, especially pregnant females, may have been under-sampled. The estimate of 1,000 bears in this status report is considered dated. The final year of a mark-recapture inventory was completed in fall 2005; a new subpopulation estimate should be available soon.

Based on the estimate of 1,000 bears, the total harvest by Nunavut, Ontario, and Québec appears to be sustainable. Recent analysis of coastal survey data (Stirling *et al.* 2004) suggests that polar bear numbers in SH have remained unchanged in recent years. However, Stirling *et al.* (1999) and Derocher *et al.* (2004) contend that climate-related reductions in sea ice appear to have resulted in declines in body condition and in reproductive rate in the Western Hudson Bay subpopulation. A similar pattern of decline in body condition was documented for the SH subpopulation when comparing bears captured in 1984–86 with those captured in 2000–04 (M. Obbard, unpubl. data); however, it is unknown whether changes in demographic parameters have occurred.

Kane Basin (KB)

Based on the movements of adult females with satellite radio-collars and recaptures of tagged animals, the boundaries of the Kane Basin (KB) polar bear subpopulation include the North Water Polynya (to the south of KB), and Greenland and Ellesmere Island to the west, north, and east (Taylor *et al.* 2001b). Polar bears in Kane Basin do not differ genetically from those in Baffin Bay (Paetkau *et al.* 1999). 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, this subpopulation has occasionally been harvested by hunters from Grise Fiord since 1997, and continues to be harvested on the Greenland side of Kane Basin. In some years, Greenland hunters have also harvested polar bears in western Kane Basin and Smith Sound (Rosing-Asvid and Born 1990, 1995).

Few polar bears were encountered by researchers along the Greenland coast from 1994 through 1997, possibly because of previously intense harvest pressure by Greenland hunters. The current estimate of the KB subpopulation is 164 (SE=35) (M.K. Taylor, unpubl. data) and the best estimate of the Greenland kill is 10 bears per year during 1999–2003 (Born 2005, Born and Sonne 2005). However, the actual number being taken by Greenland hunters is uncertain (Born 2001, Born and Sonne 2005) and must be validated. The Canadian quota for this subpopulation is five and if Canadian Inuit continue to harvest from this area, over-harvest and subpopulation depletion could occur. The annual combined Canadian and Greenlandic take of 10–15 from the KB subpopulation is unsustainable (Table 1). Although the habitat appears suitable for polar bears on both the Greenland and Canadian sides of Kane Basin, the densities of polar bears on the Greenland (harvested) side were much lower than on the Canadian side, suggesting that this subpopulation may have been larger in past years, and could be managed for subpopulation increase. Co-management discussions between Greenland and Canada are continuing; Greenland has decided to move to a quota system taking effect from 1 January 2006 (Lønstrup, this volume).

Baffin Bay (BB)

Based on the movements of adult females with satellite radio-collars and recaptures of tagged animals, the area in which the Baffin Bay (BB) 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.* 2001b). 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.* 2001b). A study of micro-satellite variation did not reveal any genetic differences between polar bears in Baffin Bay and Kane Basin, although Baffin Bay bears differed significantly from Davis Strait and Lancaster Sound bears (Paetkau *et al.* 1999). An initial subpopulation estimate of 300–600 bears was based on mark-recapture data collected in spring (1984–1989) in which the capture effort was restricted to shore-fast ice and the floe edge off northeast Baffin Island (R.E. Schweinsburg and L.J. Lee, unpubl. data). However, recent work has shown that an unknown proportion of the subpopulation is 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 ashore in summer retreat areas on Bylot and Baffin islands (Taylor *et al.* 2005). Taylor *et al.* (2005) estimated the number of polar bears in BB at 2,074 bears (SE = 266).

The BB subpopulation is shared with Greenland, which does not limit the number of polar bears harvested. Using mark-recapture, Taylor *et al.* (2005) estimated the Greenland annual removal at 18–35 bears for the period 1993–1997. However, Born (2002) had reported that the estimated Greenland average annual catch of polar bears from the BB subpopulation was 73 over the period 1993-1998. More recently, Born and Sonne (this volume) indicated the BB average annual kill from 1999-2003 for Greenland was 115 (range: 68-206 bears per year) with an increasing trend. In December 2004, based on reports from Inuit hunters that polar bear numbers in BB had grown substantially, Nunavut increased its BB polar bear quotas from 64 to 105 bears.

The BB subpopulation appears to be substantially over-harvested. The current (2004) estimate of subpopulation size is less than 1,600 bears based on simulations using the pooled Canadian and Greenland harvest records (Table 1). Co-management discussions between Greenland and Canada are ongoing. At the 2005 meeting of the IUCN/SSC Polar Bear Specialist Group, Greenland indicated its intention to adopt a quota system effective 1 January 2006.

Davis Strait (DS)

Based on the movements made by tagged animals and, more recently, of adult females with satellite radio-collars, the Davis Strait (DS) subpopulation includes polar bears in 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. When bears occur in the latter area they are subject to catch from Greenlanders (Stirling and Kiliaan 1980, Stirling *et al.* 1980, Taylor and Lee 1995, Taylor *et al.* 2001b). A genetic study of polar bears (Paetkau *et al.* 1999) indicated significant differences between bears from Davis Strait and both Baffin Bay and Foxe Basin. The initial subpopulation estimate of 900 bears for DS (Stirling *et al.* 1980) was based on a subjective correction from the original mark-recapture estimate of 726 bears, which was felt to be too low because of possible bias in the sampling. In 1993, the Canadian 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 (I. Stirling and M.K. Taylor, unpubl. data). Traditional ecological knowledge also suggested that the subpopulation had increased over the last 20 years. The principal justification for this adjustment is based on the observation that the annual harvest has been sustained for the last 20 years and on non-quantitative observations that continue to suggest the subpopulation has increased.

The IUCN Polar Bear Specialist Group has at its 11th, 12th and 13th meetings indicated that the DS subpopulation was either stable or perhaps declining due to over-harvest (IUCN/SSC Polar Bear Specialist Group 1995, 1998, 2002).

In December 2004, Nunavut increased its polar bear quota in DS by 12 bears based on Inuit reports that the subpopulation had increased since 1996. In order to sustain this increased level of harvest, Nunavut estimated that the size of the DS subpopulation would have to be at least 1,650 bears; this is the subpopulation estimate currently used by Nunavut for management purposes. A mark-recapture inventory is currently underway to assess the size of the DS subpopulation. Within Canada, this subpopulation is harvested by Inuit from Nunavut, Québec, and Labrador. The combined harvest by these jurisdictions, Nunavut and Greenland (*c.* one per year in Greenland during 1999–2003; Born and Sonne, this volume) totalled 65 (Table 1). Co-management discussions between Greenland and Canada are continuing, and Greenland has indicated its intention to move to a quota system taking effect from 1 January 2006. A population inventory began in summer of 2005 to develop a scientific estimate of subpopulation numbers. Survival and recruitment rates used for risk assessment are based on the detailed rates obtained for the adjacent Baffin Bay subpopulation (Taylor *et al.* 2005).

Arctic Basin (AB)

The Arctic Basin subpopulation is a geographic catch-all to account for bears that may be resident in areas of the circumpolar Arctic that are not clearly part of other subpopulations. Polar bears occur at very low densities here and it is known that bears from other subpopulations use the area (Durner and Amstrup 1995). As climate warming continues, it is anticipated that this area may become more important for polar bears as a refugia but a large part of the area is over the deepest waters of the Arctic Ocean and biological productivity is thought to be low.

Threats and uncertainties

Anthropogenic and natural changes in arctic environments, as well as new recognition of the shortcomings of our knowledge of polar bear ecology, are increasing the uncertainties of polar bear management. Higher temperatures and erratic weather fluctuations, symptoms of global climate change, are increasing across the range of polar bears. Following the predictions of climate modellers, such changes have been most prevalent in arctic regions (Stirling and Derocher 1993, Stirling and Lunn 1997, Stirling *et al.* 1999, Derocher *et al.* 2004), and have already altered local and global sea-ice conditions (Gloersen and Campbell 1991, Vinnikov *et al.* 1999, Serreze *et al.* 2000, Parkinson and Calvalieri 2002, Comiso 2002, 2003, Gough *et al.* 2004). Because changes in sea-ice are known to alter polar bear numbers and productivity (Stirling and Lunn 1997, Stirling *et al.* 1999, Derocher *et al.* 2004), effects of global climate warming can only increase future uncertainty and may increase risks to the welfare of polar bear subpopulations. Uncertainty about effects of climate change on polar bears must be included in future management and conservation plans. In the face of climate change, the need for rigorous scientific information will increase.

Persistent organic pollutants, which reach arctic regions via air and water currents, also increase uncertainty for the welfare of polar bears. Recent studies document new pollutants in polar bear tissues (Smithwick *et al.* 2005, Verrault *et al.* 2005, Muir *et al.* 2006). The effects of pollutants on polar bears are only partially understood. Levels of such pollutants in some polar bear subpopulations, however, are already sufficiently high that they may interfere with hormone regulation, immune system function, and possibly reproduction (Wiig *et al.* 1998, Bernhoft *et al.* 2000, Skaare *et al.* 2000, 2001, Henriksen *et al.* 2001). Subpopulation level impacts on polar bears are unknown, at present, but reproductive and survival rates may be affected (Derocher *et al.* 2003, Derocher 2005).

Our understanding of polar bear subpopulation dynamics has greatly improved with increasing development of analysis methods (Lebreton *et al.* 1992, Amstrup *et al.* 2001, McDonald and Amstrup 2001, Manley *et al.* 2003, Taylor *et al.* 2002, 2005). These new tools suggest that previous estimates of subpopulation parameters and numbers can be biased. Vital rates are subpopulation specific, and different from the generalized rates that were often used to generate previous status reports (Taylor *et al.* 1987). Additionally, computer simulations (e.g., Taylor *et al.* in review) suggest that harvesting polar bear subpopulations at or near maximum sustained yield puts the subpopulation at greater risk than previously believed.

The International Polar Bear Agreement

In the early 1960s, great concern was expressed about the increasing harvest of polar bears. In 1965, representatives from the five "polar bear countries" met in Fairbanks, Alaska to discuss protection of polar bears. At the time that this first international meeting was convened, there was little management in effect except for the USSR, where polar bear hunting was prohibited in 1956 (Prestrud and Stirling 1994). At this meeting the following points were agreed upon:

- The polar bear is an international circumpolar resource.
- Each country should take whatever steps are necessary to conserve the polar bear until the results of more precise research findings can be applied.
- Cubs, and females accompanied by cubs, should be protected throughout the year.
- Each nation should, to the best of their ability, conduct research programmes on polar bears within its territory.
- Each nation should exchange information freely, and IUCN should function to facilitate such exchange.
- Further international meetings should be called when urgent problems or new scientific information warrants international consideration.
- The results of the First International Scientific Meeting on the polar bear should be published.

Following the first international meeting on polar bear conservation, the IUCN Polar Bear Specialist Group (PBSG) was formed to coordinate research and management of polar bears on an international basis. In addition, this group took on the role of developing and negotiating the Agreement on the Conservation of Polar Bears and Their Habitat (the Agreement). That Agreement was signed in Oslo, Norway in May 1973 and came into effect for a 5-year trial period in May 1976. The Agreement was unanimously confirmed for an indefinite period in January 1981.

Article VII of the Agreement stipulates that: "The Contracting parties shall conduct national research programmes on polar bears, particularly research relating to the conservation and management of the species. They shall as appropriate coordinate such research with the research carried out by other Parties, consult with other Parties on management of migrating polar bear populations, and exchange information on research and management programmes, research results, and data on bears taken." To meet the conditions of Article VII of the Agreement, the IUCN PBSG meets every 3–5 years.

The Agreement did not provide for protection of female polar bears accompanied by cubs or for the cubs themselves. Annex E to the Agreement drew attention to the need for this protection (Appendix 2). In 1997, the PBSG reviewed Annex E and reaffirmed the need for special protection measures for adult females (Appendix 2), but noted that the occasional take of cubs for cultural and nutritional purposes by subsistence users did not present a conservation concern.

The importance of the Agreement

A primary goal of the Agreement was to limit the hunting of polar bears to sustainable levels. Because so many management changes had already been put in place during the period when the Agreement was being negotiated, there was little detectable impact immediately following it being signed and ratified (Prestrud and Stirling 1994). However, there is no doubt that the knowledge that the Agreement was being negotiated, and was likely to be successful, was a significant stimulus (Fikkan *et al.* 1993). The Alaskan harvest rate was reduced by 50% following the MMPA in 1972.

To date, the Agreement has been the most important single influence on the development of internationally coordinated management and research programmes, which have ensured the survival of polar bears (Prestrud and Stirling 1994). The Agreement is not enforceable by law in any of the countries that have signed it, a weakness that has been identified in previous reviews of international wildlife law. It has been successful in bringing the harvest of polar bears within sustainable limits for most populations, while still facilitating harvest by local people. Most of the original habitat of polar bears is still intact (although not protected) and uninhabited. The polar bear is the only bear, and probably one of the only large carnivores, that still occurs throughout most of its original range.

The IUCN Polar Bear Specialist Group

The work of the PBSG has always been important to the Agreement. Initially, membership was limited to government biologists working on polar bears because one of the principal tasks was negotiation of the Agreement. After the Agreement was signed, "Invited Specialists" were included to facilitate the input of experts in fields like population dynamics and physiology. One of the reasons the PBSG has been so successful is that members have been appointed by government agencies and have usually been polar bear specialists as well. Because governments have been more directly involved in the work of this Specialist Group, they have also had a vested interest in its success. Consequently, the people going to meetings have had a fair amount of authority to make decisions and commitments.

The PBSG has no regulatory function and the main function is to promote cooperation between jurisdictions that share polar bear populations, facilitate communication on current research and management, and monitor compliance with the agreement. The PBSG is not an open forum for public participation; it is a technical group that meets to discuss technical matters that relate to the Agreement. The deliberations and resolutions adopted by the PBSG are available to the public as are the published proceedings of the meetings. They have been published in the IUCN Occasional Papers Series of the IUCN Species Survival Commission (SSC).

One strength of the group has always been its small size. Because of the relationship of the PBSG to the Agreement, membership must reflect not only technical expertise in polar bear research and management, but also equal representation of the nations signatory to the Agreement. For this reason, each nation is entitled to designate three full members. However, in matters that require a vote (*e.g.*, elections and resolutions), each member nation is allowed only one vote. Each nation is at liberty to independently determine their process for casting a single vote. Only government-appointed members may vote. Government-appointed members are chosen by their respective governments.

In addition to government-appointed members, the chairman may, as per IUCN guidelines for membership in Specialist Groups, appoint five full members so long as they qualify as polar bear specialists. Full members appointed by the chair and government appointed members constitute the membership of the PBSG between meetings. The chair-appointed members are considered members until the election of a new chairman, which occurs at the end of each meeting. In this way the number of members of the PBSG will not exceed 20.

A third category titled: "Invited Specialists" is recognised. These individuals are not considered full members, but are invited to participate in a given meeting or parts of the meeting as designated by the Chairman.

These guidelines are intended to maintain the integrity of the PBSG as a small working group of technical specialists on polar bears while still ensuring that it is responsible to the governments signatory to the Agreement, the IUCN, and the international conservation community.

Conservation Action Plan for polar bears

The PBSG considers the Agreement to be an action plan for the conservation of polar bears.

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