Polar Bears at Risk

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A WWF Status Report

by
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Foreword

Contrary to popular perception, the Arctic is far from being a barren vast open space. It has the largest unfragmented wilderness in the northern hemisphere, surrounded by shelf seas that are among the most biologically productive in the world. This is the kingdom of the polar bear—an ambassador for arctic nature and a symbol of the impacts that global warming is increasingly having around the world.

As the UN Intergovernmental Panel on Climate Change (IPCC) laid out in its Third Assessment Report: "Climate change in the polar region is expected to be among the greatest of any region on Earth… The Arctic is extremely vulnerable to climate change, and major physical, ecological, and economic impacts are expected to appear rapidly… A variety of feedback mechanisms will cause an amplified response, with consequent impacts on other systems and people."

Arctic nations should be leading the charge against climate change. Instead, Canada, Russia and the United States—large global warming polluters and home to most of the world's polar bears—have been in the camp of those slowest to act on global warming. It is imperative that all of these countries ratify the Kyoto climate treaty and put in place strong national policies to meet or beat Kyoto's emissions reduction targets. While Kyoto is currently the world's only defence against global warming, its targets are the bare minimum that countries should attain if we are to have a chance of preventing global warming from rendering a wide range of species extinct.

The rapid pace of change in the Artic tells us that there is no time to lose in confronting this problem. The warming trend has already resulted in a three per cent decrease per decade in the extent of sea ice since the 1970s and an increase in the number of melt days each summer. Continued shrinkage in sea ice extent will have severe repercussions on life in the Artic that will ripple through the entire arctic marine food web up to the polar bear.

As a case in point, *Polar Bears at Risk* highlights the immediate threat to polar bear populations from longer ice-free periods in the Arctic. The earlier break-up of sea ice limits the bears' hunting season and forces them to come ashore earlier. Shortening the bears' hunting season by just two weeks can lead to an eight per cent weight loss. Not only does the inability to build up sufficient fat reserves cause polar bears problems in waiting out the fasting season but the inability of mothers to lactate leads to greater mortality among cubs. The problem is most acute among the Hudson Bay population, an important source of tourism revenue to Canada.

Through its Arctic Climate Change Focal Project, WWF is supporting and working with experts and concerned groups to improve understanding of climate change impacts and find ways of strengthening the resilience of life in the Arctic to global warming.

Jennifer Morgan
Director
WWF Climate Change Program
May 2002

Summary

Polar bears, the world's largest terrestrial carnivore, spend much of their lives on the arctic sea ice. This is where they hunt and move between feeding, denning, and resting areas. The world population, estimated at 22,000 bears, is made up of 20 relatively distinct populations varying in size from a few hundred to a few thousand animals. About 60 per cent of all polar bears are found in Canada. In general, the status of this species is stable, although there are pronounced differences between populations.

Reductions in the extent and thickness of sea ice has lead the IUCN Polar Bear Specialist Group to describe climate change as one of the major threats facing polar bears today. Though the long-term effects of climate change will vary in different areas of the Arctic, impacts on the condition and reproductive success of polar bears and their prey are likely to be negative.

Longer ice-free periods resulting from earlier break-up of sea ice in the spring and later formation in the fall is already impacting polar bears in the southern portions of their range. In Canada's Hudson Bay, for example, bears hunt on the ice through the winter and into early summer, after which the ice melts completely, forcing bears ashore to fast on stored fat until freeze-up in the fall. The time bears have on the ice to hunt and build up their body condition is cut short when the ice melts early. Studies from Hudson Bay show that for every week earlier that ice break-up occurs, bears will come ashore 10 kg lighter and in poorer condition. It is likely that populations of polar bears dividing their time between land and sea will be severely reduced and local extinctions may occur as greenhouse gas emissions continue to rise and sea ice melts.

Expected changes in regional weather patterns will also impact polar bears. Rain in the late winter can cause maternity dens to collapse before females and cubs have departed, thus exposing occupants to the elements and to predators. Such rains also destroy the denning habitat of ringed seals, the polar bears' primary prey. Declines in the ringed seal population would mean a loss of food for polar bears. A trend toward stronger winds and increasing ice drift observed in some parts of the Arctic over the last five decades will likely increase energy expenditures and stress levels in polar bears that spend most of their lives on drifting sea ice.

Polar bears face other limiting factors as well. Historically, the main threat to polar bears has been hunting. Satisfactory monitoring information has been obtained for most polar bear populations in recent years, however there is concern about hunting in areas without formal quota systems, such as Greenland. A range of toxic pollutants, including heavy metals, radioactivity, and persistent organic pollutants (POPs) are found throughout the Arctic. Of greatest concern are the effects of POPs on polar bears, which include a general weakening of the immune system, reduced reproductive success and physical deformities. The expansion of oil development in the Arctic poses additional threats; for example, disturbances to denning females in the Arctic National Wildlife Refuge in Alaska could undermine recruitment of the Beaufort Sea polar bear population.

These threats, along with other effects of human activity in the Arctic, combine to pressure polar bears and their habitat. Large carnivores are sensitive indicators of ecosystem health and can be used to define the minimum area necessary to preserve intact ecosystems. WWF has identified the polar bear as a unique symbol of the complexities and interdependencies of the arctic marine ecosystem as it works toward its goal of preserving biodiversity for future generations.

Introduction

Scientists have confirmed that human-induced global warming is a reality. Over the past century, the global average surface temperature increased by about 0.6°C and the effects of this shift are becoming increasingly visible: ocean temperatures and sea levels have risen, the frequency of El Niño events has increased, and there has been an overall reduction in the extent and thickness of sea ice in polar regions (IPCC 2001a).

According to the Intergovernmental Panel on Climate Change (IPCC), even a small increase in global mean temperature may threaten a range of species with local or global extinction (IPCC 2001b). To estimate the extent to which species are threatened, Malcolm et al. (2002) investigated changes in terrestrial habitats resulting from global warming. They found that more than 80 per cent of ecoregions will suffer plant and animal extinctions due to warming resulting from a doubling of CO_2 in the atmosphere as compared to pre-industrial levels. Marine habitats, and species such as the polar bear which depend on them, are similarly vulnerable to the effects of global warming.

The IUCN Polar Bear Specialist Group considers climate change to be one of the major threats to polar bear populations. The effects of reductions in sea ice extent and thickness, shorter periods of maximum ice extent, as well as changes in sea ice dynamics and structure, may vary in different areas of the Arctic, but all have the potential to negatively influence the condition and reproductive success of polar bears and their prey.

Polar bears face other limiting factors as well. Hunting, toxic pollution, oil development, and other human activities all combine to pressure the species and its habitat. In this report we examine the effects of climate change on polar bear habitat, and put this in the context of other limiting factors, then describe the management of and conservation opportunities for this top predator.

The Bear of the Sea

The polar bear is the world's largest terrestrial carnivore, but its Latin name—*Ursus maritimus*—reflects the fact that it spends most of its life at sea. Polar bears are excellent swimmers. They can spend several hours at a time in the icy waters and cover long distances. Their preferred habitat, however, is on top of the ice that covers the arctic seas most of the year.

Ringed seals (*Phoca hispida*) are the polar bear's primary prey. These seals are a particularly energy-rich food-source for polar bears due to their high body fat content; ringed seal pups are up to 50 per cent fat at the time they are weaned. Adult bears will typically eat only the fat of their kill, whereas younger animals with a greater protein requirement for growth will eat some of the meat as well. Polar bears generally stalk their prey when the seals are on the ice resting, when they emerge from the water near the ice edge, or at breathing holes kept open by the ringed seals in the solid ice. In the spring, polar bears commonly seek out areas where ringed seal pups are kept in snow lairs dug out on the ice. The bears locate such lairs by smell and sound, and then rear up and crash through the roof of the lair to catch the pups.

Bears also prey upon bearded (*Erignathus barbatus*) and harp (*Phoca groenlandica*) seals, and when the opportunity arises young walrus (*Odobenus rosmarus*) and beluga whale (*Delphinapterus leucas*), narwhal (*Monodon monoceros*), fish, and seabirds and their eggs (Smith 1980, DeMaster and Stirling 1981).

A thick layer of fat serves both as insulation against the cold and as an energy reserve. Polar bears will devour large amounts of fat during periods when prey is available. The largest proportion of a polar bear's annual caloric intake occurs between late April and mid-July, when ringed seal pups are abundant. Ample access to food in this period is critical for maintaining body condition and ensuring reproductive success. When food is unavailable, such as during the ice-free season, polar bears fast for protracted periods. These fasting periods can last three to four months and up to eight months for pregnant females in some populations. Polar bears are unique in that they can switch from a normal metabolic state to a slowed-down hibernation-like condition in about 7-10 days at any time of the year when food is scarce (Derocher et al. 1990).

Adult males typically measure 200 to 250 cm from the tip of the nose to the tip of the tail and weigh 400-600 kg, while females are 180-200 cm in length and weigh 200-350 kg. Some males may reach 800 kg or more and pregnant females occasionally exceed 500 kg. In populations that are not over-harvested, females live into their mid or late 20s and males generally reach their early to mid-20s.

Mating takes place in April and May, but the fertilized egg does not implant until September or October, at which time pregnant females head for denning areas. Pregnant females usually dig dens in deep snow-drifts on land, while the rest of the population remains active through the winter. In the Beaufort Sea, some polar bears dig maternity dens in snow-drifts on multi-year ice floes (Lentfer 1975; Amstrup and Gardner 1994), while in western and southern Hudson Bay cubs can be born in dens excavated in frozen peat banks (Clark et al. 1997). After about two months of gestation, the cubs are born in the den. There are usually two cubs, each weighing around 600 grams and are about the size of a guinea pig. Cubs are nursed in the den on fat-rich milk until they weigh about 10 kg and are large enough to venture out onto the sea ice, which usually occurs in March or April. In most areas cubs are weaned at 2.5 years of age, making females available for mating once every three years. Small litter sizes, late maturation and the prolonged mother-offspring bond result in low reproductive rates. This means that polar bear populations are slow to recover if reduced in numbers, particularly if the reduction is due to loss of productive adult females. (Taylor et al. 1987).

Polar bears are distributed throughout the circumpolar arctic in 20 relatively distinct populations that vary in size from a few hundred to a few thousand individuals (Figure 1, Table 1). There are estimated to be at least 22,000 polar bears worldwide, with about 60 per cent occurring in Canada.

Figure 1: Circumpolar distribution of polar bear populations (courtesy IUCN Polar Bear Specialist Group).

Table 1: Polar bear population status as determined by the Polar Bear Specialist Group in June 2001. Uncertain trends are denoted by *.

Population	Abundance Estimate	Status
Arctic Basin	unknown	unknown
Baffin Bay (BB)	2200	decreasing
Barents Sea	2000-5000	unknown
Chukchi Sea	2000+	stable*
Davis Strait (DS)	1400	decreasing*
East Greenland	2000	unknown
Foxe Basin (FB)	2300	stable
Gulf of Boothia (GB)	900	stable
Kane Basin (KB)	200	stable
Kara Sea	unknown	unknown
Lancaster Sound (LS)	1700	stable
Laptev Sea	800-1200	unknown
M'Clintock Channel (MC)	350	stable*
Northern Beaufort Sea (NB)	1200	increasing
Norwegian Bay (NW)	100	stable
Queen Elizabeth (QE)	200	unknown
Southern Beaufort Sea (SB)	1800	increasing
Southern Hudson Bay (SH)	1000	stable
Viscount Melville Sound (VM)	230	stable
Western Hudson Bay (WH)	1200	stable

The distribution of polar bears is influenced by the type and distribution of sea ice, as well as the density and distribution of the seals on which they prey. In open areas such as the Beaufort Sea, polar bears are widely dispersed throughout areas of annual and multi-year ice (Garner et al. 1994). Populations in areas over the continental shelf are dispersed along the coast in active ice areas associated with shore leads, polynyas and mixed annual and multi-year ice (Stirling et al. 1993, Stirling 1997). During summer, the ice may melt in all or part of the range of a given population so that bears are forced to spend several months on land waiting for freeze-up in the fall. This pattern is most pronounced in Canada's Hudson and James Bays (Derocher and Stirling 1990, Derocher et al. 1993, Clark et al. 1997).

Individual bears in the different populations often have different spatial requirements and habitat selection strategies. Some have small home ranges (<1000 km^2) that include both land and sea ice, where the bears spend several summer months fasting on land. Others have large home ranges (>300,000 km^2), spend almost all of their time on the sea ice where there is food, and thus do not have to fast, (Ferguson et al. 1997, 2000; Mauritzen et al. 2001). Despite these differing strategies, indicating adaptability within the species, Mauritzen et al. (2001) found that individual bears are loyal to their own strategy. They do not readily shift from, for example, a small-range, land-based fasting strategy to a large-range sea-ice strategy.

The general population status of polar bears is currently stable, though there are pronounced differences between the various populations. Some populations are stable, some seem to be increasing, and some are decreasing due to various pressures. The status of some populations is not well documented.

Polar bears are on Appendix II[1] of the Convention on International Trade in Endangered Species (CITES) and are currently classified as Lower Risk/Conservation Dependent[2] on the IUCN Red List of Threatened Species. Individual countries with polar bear populations also have individual definitions of the population status and management recommendations for their respective populations.

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[1] CITES Appendix II lists species that are not currently threatened with extinction but that become so unless trade is closely controlled.

[2] A taxon is Lower Risk when it has been evaluated and does not satisfy the criteria for any of the categories Critically Endangered, Endangered or Vulnerable; Conservation Dependent describes taxa which are the focus of a continuing taxon-specific or habitat-specific conservation programme targeted towards the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above whithin a period of five years.

Climate Change Impacts

Sea ice is the predominant feature of the arctic seas, and global warming caused by greenhouse gas emisions is expected to cause a reduction in its thickness and extent. Arctic shelf seas are among the most productive in the world and large numbers of organisms from all trophic levels can be found along ice edges, leads and polynyas where the interaction of ice, sunlight and water currents is greatest (Sakshaug et al. 1994).
Reductions in the extent of sea ice will undermine the productivity of the northern oceans. Of concern as the ice melts is the loss of ice-dependant prey species for predators like the polar bear (Tynan and DeMaster, 1997). The seasonal cycle of melting ice creates vertical mixing in the ocean column and allows nutrient-rich water to reach the surface. Colony-building diatoms and blue-green algae flourish on the underside of ice floes. In the spring, as sunlight returns to the northern high latitudes and the pack ice retreats north, these algae seed a bloom of phytoplankton in the layer of nutrient-rich brackish water that forms on top of the cold, dense sea water below. Zooplankton and small crustaceans, such as copepods, amphipods and krill, feed on this bloom. These in turn, serve as food for fish (particularly arctic cod), seals, seabirds, and other predators. But it is in the open water of leads and polynyas where productivity is highest and top level predators—like the polar bear—feast on the abundance of ice-dependent species assembled there (Sakshaug et al. 1994). Due to its position at the top of the arctic marine food web, the polar bear is an ideal species through which to monitor the cumulative effects of climate change in the arctic marine ecosystem (Stirling and Derocher 1993).
Indigenous communities along the coast of the northern Bering and Chukchi Seas have noticed substantial changes in the marine ecosystem since the 1970s. Alaska Natives, for example, have experienced warmer winters, early spring break-up, and thinner than usual ice (Pungowiyi 2000). This traditional knowledge echoes the scientific evidence. Throughout the 20th century, the following scientific observations have been made:

- Although not geographically uniform, air temperatures in the Arctic have increased by about 5°C over the last 100 years (Serreze et al. 2000).
- Since 1972, a 10 per cent decrease in snow-cover extent across the northern hemisphere has been observed (Brown, 2000).
- Between 1978 and 1996, arctic sea ice extent decreased by approximately 3 per cent per decade (Parkinson et al. 1999); Figure 2 illustrates that spring sea ice extent in the Nordic Sea has been reduced by 33 per cent over the past 135 years (Vinje 2001).

Sea ice is critical to the survival of polar bears. It is the platform from which they hunt because it is there that their primary prey—ringed and bearded seal—are found. Ringed and bearded seals are in turn dependent on sea ice as it is there that they rest, give birth and raise their pups. Regional variation in the seasonal distribution and extent of sea ice has been shown to have significant effects on the survival of seals and consequently on polar bears (Stirling 1997).
While different model projections of the future distribution of sea ice differ quantitatively from one to another, they agree that sea ice extent and thickness will continue to decline throughout the 21st century as the climate warms. Figure 3 illustrates this with annual mean ice extent results from two coupled models, the Geophysical Fluid Dynamics Laboratory (GFDL) Model from the United States and the Hadley Centre Model from the United Kingdom. Although the Hadley Centre Model underestimates northern hemisphere sea ice extent and thickness, the simulations of ice extent decline over the past 30 years are in good agreement and predict substantial decreases in sea ice extent and thickness over the next 50 years (Vinnikov et al. 1999). The GFDL projection shows that by the year 2050 sea ice extent will be reduced to about 80 per cent of the area it covered during the mid-1900s.

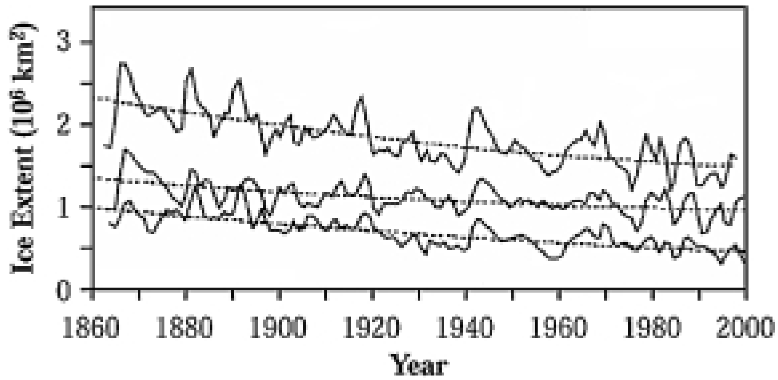

Figure 2: The time series of April sea ice extent in the Nordic Sea (1864-1998) shows a 33 per cent reduction in sea ice extent for the entire region (top curve) and its eastern (middle) and western (bottom) areas (after Vinje 2001).

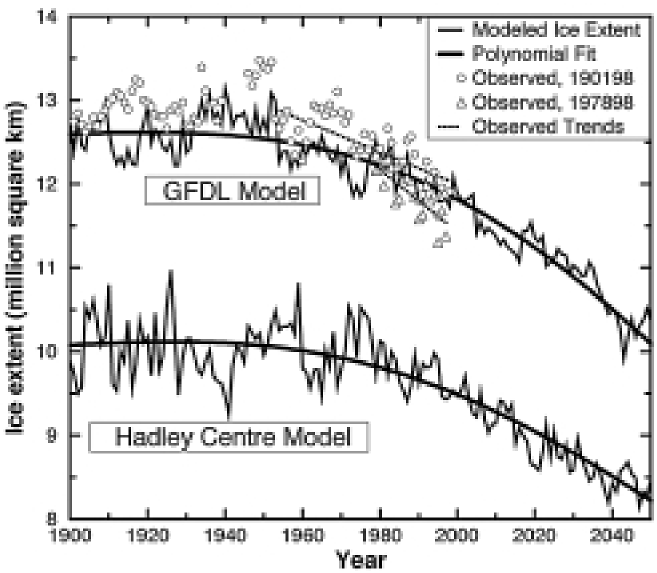

Figure 3: Observed and modelled variation of annual averages of arctic sea ice extent. Reprinted with permission from Vinnikov et al. 1999. Copyright 1999 American Association for the Advancement of Science.

Computer modelling by Gordon and O'Farrell (1997) predicts a 60 per cent loss of summer sea ice in the Arctic for a doubling of CO2 which translates to an increase in the summer ice-free season from 60 to 150 days. Stirling et al. (1999) suggest that hunting success in the spring enables polar bears to maximize the fat reserves necessary for survival, reproduction and lactation through the rest of the year. Longer ice-free periods resulting from earlier break-up in the spring and later sea ice formation in the fall will impact polar bear numbers in the southern portions of their range such as Hudson Bay. In these areas, bears hunt on the ice through the winter and into early summer, after which the ice melts completely so that they are forced to go ashore and fast on their stored fat until freeze-up in the fall. Thus, if the ice breaks up earlier in the spring because of climatic warming, it shortens the amount of time polar bears can hunt seals and build up their body condition. Studies from Hudson Bay show that for every week earlier that break-up occurs bears will come ashore 10 kg lighter (Stirling and Derocher 1993) and in poorer condition (Stirling et al. 1999).

Evidence has been given suggesting that changes in sea ice associated with a 1ºC warming in Hudson Bay could result in a weight loss of 22 kg in females (about 8 per cent of total body weight) due to fewer days spent on the ice hunting (Stirling and Derocher 1993). Derocher and Stirling (1996) found in western Hudson Bay during the period 1980-1992 that the survival of cubs from spring to the end of the ice-free period in autumn was 44 per cent, with the main cause of death being either an absence of food or lack of maternal fat for lactation.

With reproductive success tied closely to body condition (Derocher and Stirling 1996), polar bears will likely be grossly reduced in number populations that divide their time between land and sea; local extinctions may occur as greenhouse gas emissions continue to rise and sea ice melts.

In addition to changes in sea ice extent, climate change in the Arctic is expected to bring increased precipitation (IPCC 2001b). Such a change would affect polar bears indirectly. On the one hand, ringed seals could benefit from increased snowfall. Lydersen and Gjertz (1986) investigated ringed seal lairs on Svalbard, and found that birth lairs have significantly more snow cover than lairs of adult males or sub-adults. This indicates selection by females with pups to use the heavier snow-drifts that provide added protection from predators, and subsequently results in increased pup survival. But if increased precipitation comes in the form of rain, this would melt the lairs. The population effects of this could be devastating due to the exposure of pups and increased predation (Furgal et al. 1996; Hammill and Smith 1991). In a future climate with significant increases in the frequency or amount of rain, Stirling and Derocher (1993) speculate that the increased predation by both polar bears and arctic foxes could depress the seal population enough to cause a significant decline in polar bear numbers.

Little is known about how polar bears might adapt to changes in the availability of ringed seals, although since different seal species have different affinities to specific ice characteristics (Burns 1981; Ronald and Healey 1981; Frost and Lowry 1981), the changing climate and ice conditions might favour other seal species, resulting in increases in those populations. If so, it is likely that such species would become increasingly more prevalent in the bears' diet. For example, in a preliminary analysis of fatty acids in polar bears in western Hudson Bay done by Drs. Sara Iverson of Dalhousie University and Ian Stirling of the Canadian Wildlife Service, it appears that the proportion of harbour and bearded seals in the bears' diet has recently increased (I. Stirling, pers. comm.).

Of further concern in a future of increased precipitation is the effect of adverse weather on polar bear maternity dens. Rain in the late winter can cause dens to collapse before females and cubs have departed (Clarkson and Irish 1991; Stirling and Derocher 1993). Warm spring temperatures can also thaw out a den, thus exposing its occupants to the elements and to predators. A trend toward stronger winds and increasing ice drift has been observed in some parts of the Arctic over the last five decades (Proshutinsky and Johnson 1997, Proshutinsky et al. 1999). Should this trend continue, Mauritzen (2001) shows that it would likely increase energy expenditures and stress for those polar bear populations where bears spend most or all of their time on the ice.

Temperature changes in the Arctic caused by greenhouse gas emissions have led to reductions in sea ice extent and longer ice-free periods. This trend is expected to continue throughout the 21st century.
While the effects of shorter periods of maximum ice extent, as well as changes in sea ice dynamics and structure, may vary in different areas of the Arctic, they represent the greatest challenge to the conservation of polar bears.

The Hunting of Polar Bears

Though much of the traditional harvesting from local communities has been sustainable, the IUCN Polar Bear Specialist Group (PBSG) documents that, both historically and currently, the main threat to polar bears is over-harvesting (Derocher et al. 1998).

The PBSG regularly reviews results of ongoing monitoring of the size, age and gender distributions of polar bear populations provided by the individual countries. For those populations that have functioning monitoring programs, the PBSG can estimate the status of the population.

Satisfactory monitoring information has been delivered for fourteen of the twenty populations of polar bears in recent years (see Table 1, page 12). Of these, ten are showing stable population numbers, two seem to be increasing, and two are decreasing.

Six of the twenty polar bear populations have unknown status. Some of these, for example the Arctic Basin and Queen Elizabeth populations, are in areas with few or no humans and are not harvested. However, in other areas, such as East Greenland, there is a harvest but there are no quota systems in place. The PBSG has expressed concern about this latter situation, and urges governments to initiate sound monitoring in these areas so that population estimates can be made and trends documented. Only then can the sustainability of the harvest be secured.

Today, legal hunting of polar bears by non-native sport hunters is only found in Canada. The community itself decides which proportion of the quota it has been issued is to be used for outside sport hunters.

In some of the areas lacking monitoring, such as Russia, little information is available on current hunting practices. Since it is not known if removal of polar bears is balanced against the sustainable yield of a known population size in such areas, there is reason for concern regarding the sustainability of these practices.

Pollution in the Arctic

Although polar bears live in a seemingly pristine habitat, with limited human activity, it is becoming increasingly evident that they are exposed to, and in some cases heavily impacted by, pollution and contaminants (AMAP 1997).

Local pollution can have serious effects on individuals or groups of bears. Though this is a problem to be taken seriously at the local management level, such pollution seldom threatens whole populations of polar bears. Long-range pollutants, stemming primarily from industrialized countries to the south, represent the most serious pollution-related threat to polar bears at the population level. (AMAP 1997).

High levels of heavy metals have been measured both in seals and polar bears (AMAP 1997). Some of these, for example mercury and cadmium, bioaccumulate, that is they are not readily broken down in the animal but accumulate in vital organs as the individual grows older. Mercury is a neurotoxin and can negatively affect brain development of young bears, as well as disrupt sperm production in males (AMAP 1997). Knowledge of sources, distribution pathways, and natural background values and fluctuations of heavy metals is currently limited for the Arctic. There is no evidence that heavy metals are affecting the general health of or otherwise threatening the overall polar bear population.

The general level of radioactivity in the arctic marine ecosystem has increased in the last 50 years. These increases are due mainly to testing of nuclear bombs, emissions and discharges from nuclear reprocessing plants, and accidents at nuclear power stations (AMAP 1997). Though there is no documentation of elevated levels of radioactivity in the overall polar bear population, this form of pollution remains a threat. Many reactors, both in ships, submarines and power plants, as well as large amounts of nuclear waste, are located in the Arctic, mainly in northwestern Russia. A major release of radioactivity could have serious effects on the entire marine food web in the adjacent seas, and thus on one of the top predators of this food web, the polar bear (Derocher et al. 1998).

Persistent organic pollutants (POPs) include a wide range of toxic substances, including industrial chemicals such as PCBs, by-products of industrial processes (e.g. dioxins and furans), as well as pesticides like DDT, dieldrin and lindane, and herbicides. In addition to persisting in the environment for a long time, POPs are of special concern because they are passed from species to species in increasing concentrations through the food web, and they often accumulate in vital organs over time (AMAP 1997).

As the top predator in the arctic marine ecosystem, polar bears are exposed to high levels of such environmental pollutants. Local sources within the Arctic include military installations, industry, and local application of pesticides. Long-range POPs transported to and concentrated in the Arctic via atmospheric and riverine pathways originate from the use of pesticides and other chemicals, some of which are banned in many countries, but used extensively in Russia, eastern Europe, and Asia (AMAP 1997). Though some of the local sources are significant, the long-range POPs represent the most serious population-level threat to polar bears.

Normal regulation of vitamin A and thyroid hormones is important for a wide range of biological functions, such as growth, cell differentiation, reproduction, behaviour, and the immune system. Skaare et al. (2000) have revealed that bears from Svalbard with high blood levels of PCBs, HCB, and HCHs had reduced levels of vitamin A, and that bears with high levels of PCBs and HCB showed weakened thyroid hormone systems (indicated by ratios of total versus free T4 thyroid hormone levels).

In six of the 16 sites that contributed to the State of the Arctic Environment Report (AMAP 1997) —Svalbard, North-Eastern Greenland, Wrangel Island, Eastern Hudson Bay, McClure Strait—the levels of PCBs in polar bear blubber were found to be higher than levels shown to adversely affect reproduction in mink (AMAP 1997). Several of the other sites showed values very close to this threshold value of 10,000 nanograms per gram fat. Different animal species show widely different tolerance levels towards PCBs. The levels measured in polar bears have, however, spurred further research into the effects of POPs on polar bear reproduction on Svalbard and in Canada. Alaska also has ongoing immune effects studies.

Bernhoft el al. (2000) and Skaare et al. (2000) have shown that PCBs may be weakening the polar bears' immune systems by interfering with their production of antibodies. In polar bears with high PCB levels sampled on Svalbard between 1991 and 1994, they found significantly reduced levels of the immunoglobolin antibody IgG, which is important for combating infectious diseases. Similarly, bears with high levels of the organochlorine HCB also showed reduced levels of IgG. Small cubs may be particularly vulnerable to pollution that they receive from their mothers via the high fat content of milk, which may result in higher cub mortality (Polischuk et al. 1995, 2002).

An important comparative study of immunosuppression in polar bears from Canada, where PCB exposure is relatively low, and Svalbard, where it is relatively high, is currently underway by the Norwegian Polar Institute and the Canadian Wildlife Service. In this study, bears from the two regions were caught, blood samples were taken, and they were vaccinated with standard vaccines to provoke an immune response. After several weeks the bears were recaptured and new blood samples were taken. Several immunological parameters were measured in the two blood samples, checking for differences in immunological responses in the population with high PCB exposure versus the one with low exposure. The preliminary analysis shows that PCBs limit the ability to produce antibodies following immunization, which indicates decreased resistance to infections.

Pseudohermaphroditism (the occurrence of partially-developed male genitalia in females) has been observed in 1.5 per cent of the female polar bears sampled on Svalbard in recent years (Wiig et al. 1998). This high percentage of such malformations could be the result of hormonal disruption from environmental pollutants, although the existing data are inconclusive due to the small sample size, short time series, and lack of comparable studies from other areas.

Although current research shows that POP levels in the polar bear population on Svalbard almost certainly affect the immune system, and may lead to physical abnormalities related to reproductive hormone levels in individual polar bears living in contaminated areas, the significance of these findings on the overall population has yet to be determined. It is however evident that POPs must be included as a major impact when evaluating the sum of all human-induced impacts on the populations.

There are also grounds for additional concerns. A major source of uncertainty is the range of new, man-made persistent substances that have made their way to and are concentrated in the Arctic and that currently have unknown effects. In addition there are the known toxic and persistent substances that scientists are not collecting, measuring or analysing due to lack of resources. These include both POPs and other contaminants, such as derivatives of stain repellents known as PFOS, and brominated flame retardants, which may have similar immune and reproductive impacts on polar bears as those already documented.

Oil Development

Petroleum exploration, extraction, transportation and processing in the Arctic affects polar bears and their habitat in many ways. There are large installations and operations already in place, and it is a growing industry in the Arctic. There is one true offshore oil production installation in the Arctic, in the Alaskan Beaufort Sea, but exploratory activities have taken place in the Barents, Kara, and Pechora Seas, the Sea of Okhotsk, as well as the Davis Strait and the Canadian High Arctic Islands. Further offshore development is expected, particularly in the Russian Arctic and in the Norwegian part of the Barents Sea. Onshore arctic oil installations are currently found in Russia, Canada, and Alaska. (AMAP 1997)

Oil and oil products pose serious health risks to polar bears (Øritsland et al. 1981; Hurst and Øritsland 1982; Griffiths et al. 1987). In the event of a spill in the marine habitat, oil will reduce the insulating effect of the bears' fur. The direct effect of losing insulation is that the bear must use more energy to keep warm, and must compensate for this energy loss by increasing its caloric intake, which may be difficult. Given that polar bears have very limited access to food for long periods of time, such an increased demand for food may result in starvation. Polar bears ingest oil after an oil spill both through grooming of their own contaminated pelts, and through scavenging and preying on contaminated seals, seabirds, or other food items. The ingested oil causes liver and kidney damage, as well as general physiological impairment, and it has long-term toxicity (Hurst and Øritsland 1982; Hurst, et al. 1991). Griffiths et al. (1987) concluded that even a brief oiling of the fur of a polar bear can kill it, primarily by poisoning through grooming, and that a large number of affected polar bears would likely die if an oil spill were to occur in prime polar bear habitat.

In addition to the oil itself, the extraction process can result in discharges of a number of toxic substances that may pose a threat to polar bears and their environment. These include both process chemicals, such as oil-based drilling muds, which can contain both heavy metals and POPs, and even naturally-occurring substances from the geological structure such as alkyphenols (WWF 2001; AMAP 1997). Also, disturbances due to seismic blasting, construction, transportation or operation of facilities, as well as disturbances and contamination in connection with oil spill clean-up operations can negatively impact polar bears (Derocher et al 1998).

Offshore operations pose the greatest risk, since routine emissions, spills or leaks will be discharged directly into the sea or on the sea ice. A large-scale spill at or near the ice edge, either from ship or installation, represents the most dangerous scenario for polar bears. If a major spill occurs at or near areas with high concentrations of polar bear denning sites, for example Hopen Island in the Barents Sea, it could have population-wide consequences (Isaksen et al. 1998).

There is currently no proven effective method for cleaning or controlling an oil spill in icy, arctic waters, where difficult weather conditions are common.

Despite these obvious negative impacts, and certain cases of individual bears or family units being disturbed, injured, or killed as a result of oil development, there is no evidence to date of population-level impacts on polar bears that can be attributed to such development. This can likely be attributed to the fact that oil development so far has been relatively limited in key polar bear habitats, and that precautions have been taken where obvious conflicts were identified. However, polar bear populations are expected to come under increased pressure if oil developments in the Arctic continue according to industry plans.

Impacts From Other Human Activities

In addition to petroleum development, other human infrastructure development and activity in the Arctic can also negatively impact polar bears. Such development includes industrial development, military installations, scientific research stations, new human settlements, road and pipeline construction, and finally the growing tourist industry, which increasingly brings large numbers of humans directly in to prime polar bear habitat and even denning areas.

Though polar bears, like other bears, have been shown to adapt well to human presence in some areas, such as Churchill on the Hudson Bay coast of Canada, expanding human development and activity will lead to habitat fragmentation. If human disturbances take place in areas with high concentrations of denning females, they could have negative affects on the polar bear populations of those areas. For example disturbances of denning females in the Arctic National Wildlife Refuge in Alaska could undermine recruitment to the Beaufort Sea polar bear population (Amstrup 1993).

Polar bears are curious and generally fearless by nature. They can be dangerous to human beings and can cause serious damage to property. Where there are polar bears and human beings in the same area, there is potential for conflict. Every year, polar bears are killed in self-defence, or to defend property. In Svalbard, for example, these are the only forms of removal from the population. In some populations, such incidental kills are subtracted from the overall harvest quota.

Currently, incidental kills do not alone threaten any polar bear population. For management purposes, however, it is important that incidental kills are included as part of the overall effect of humans on polar bear populations. The more people who live in or move through polar bear habitat, the larger will be the number of conflicts and killed, wounded, or stressed bears.

Polar Bear Management

The five arctic countries hosting polar bear populations; Canada, Russia, Greenland/Denmark, the United States, and Norway, all have different cultures, traditions, and histories regarding the management of the species. Historically, polar bear management was limited to the harvesting practices administered by communities within the range of any given polar bear population. Harvest was traditionally carried out to fulfil local needs for clothing and meat. It was not primarily a commercial trade, nor conducted with mechanized transport, and was therefore kept at sustainable levels. Adventure- and profit-seeking hunters from outside the Arctic harvested large numbers of polar bears from the 1700s through the 1800s and into the mid-1900s. As technology improved, introducing the use of aircraft, motorized vessels, rifles with telescopic sights, and set-gun traps, the overall harvest of polar bears in many areas intensified and became unsustainable (Prestrud and Stirling 1994).

Growing public concern over hunting and other human activities, such as oil exploration, led in 1965 to the first International Scientific Meeting on the Polar Bear being held in Fairbanks, Alaska. Following this meeting, the Polar Bear Specialist Group (PBSG) was formed under the Species Survival Commission (SSC) of the International Union for the Conservation of Nature (IUCN) to coordinate international research and management of polar bears (Prestrud and Stirling 1994).

The PBSG has no regulatory function but is rather a technical group consisting of government-appointed specialists, with equal representation of the five nations that have polar bear populations. The PBSG membership consists of up to three government-appointed members from each of the five nations, plus up to five members the Chair can appoint. The members are all specialists in the fields of polar bear biology, population dynamics, or wildlife management. The primary role of the PBSG is to promote cooperation between jurisdictions that share polar bear populations, facilitate communication on current research and management, and monitor compliance with the International Polar Bear Agreement.

As a follow-up to concerns identified by the PBSG, a series of negotiations were held with the aim of reaching an agreement on international polar bear management issues. In 1973, the five nations with polar bear populations finalized the *Agreement on the Conservation of Polar Bears.* The Agreement came into force in May 1976 and all five contracting parties unanimously reaffirmed continuation of the Agreement in January 1981. This agreement, established at the height of the Cold War, was the first environmental agreement to be signed by both western and eastern block arctic states. It was innovative for its time because it identified the need to protect entire ecosystems to ensure conservation of key species.

Under the agreement, the five polar bear nations are committed to:

- protecting polar bear habitat, especially denning areas, feeding areas, and migratory routes;
- banning the hunt of bears from aircraft and large motorized boats;
- conducting and coordinating management and research efforts;
- exchanging research results and data; and
- managing shared populations in accordance with sound conservation practices and the best available scientific information.

The Agreement allows for the taking of polar bears for scientific purposes, for preventing serious disturbances in the management of other resources, for use by local people using traditional methods and exercising traditional rights, and for protection of life and property. Though the Agreement itself is not enforceable by law in any of the countries that have signed it, most of its requirements have been partially or fully addressed by the passage of domestic legislation. As such, the Agreement is the single most important influence on the development of internationally coordinated management and research programs that have ensured the survival of polar bears. In Norway, the Agreement resulted in the closure of all polar bear harvest. The Agreement has also brought the harvest of polar bears within sustainable limits for most other populations, while still facilitating harvest by local people (Prestrud and Stirling 1994).

Each nation has established its own polar bear regulations and conservation practices. Many initial management changes were made during the process of negotiating the international Agreement, with a view to ensure compliance and to reduce the scope of unsustainable harvest. The Alaskan harvest rate, for example, was reduced by 50 per cent following the Marine Mammal Protection Act of 1972. An overview of polar bear management at the national level is given in the appendix.

Areas protected for polar bears

Article II of the International Polar Bear Agreement states that signatory nations "shall take appropriate action to protect the ecosystems of which polar bears are a part". This was innovative at the time of signing, but there has been relatively little follow-up of this part of the agreement in marine areas (Prestrud and Stirling 1994). Several terrestrial protected areas have nevertheless been established in the Arctic with the primary goal of protecting polar bear habitat.

United States/Alaska: The matrix of land ownership and legal authorities is complex in Alaska. Much of the land in federal ownership in Alaska is designated as National Wildlife Refuge or National Park, although no land or marine areas have been set aside strictly as polar bear habitat.

The Arctic National Wildlife Refuge on Alaska's north slope is the most important denning area in the United States for polar bears. The refuge is currently under pressure to be opened for oil and gas development.

Canada: Several National Parks, and National Park Reserves in northern Canada provide protection to polar bears in summer sanctuaries and denning areas, although in many cases this is coincidental.

Ontario's Polar Bear Provincial Park, at the junction of James and Hudson Bays, was established primarily to protect the world's southernmost polar bear population.

Wapusk National Park, which stretches along the Manitoba coast south of Churchill to the Ontario border, was established in 1996 to protect a core of the maternity denning areas. Managing the tourism generated by the high density of polar bears found near Churchill each autumn is a high priority for park authorities.

There are no Canadian offshore areas with polar bear protection status.

Greenland: An area in Melville Bay has been set aside as a polar bear reserve and the largest protected area in the world is the Northeast Greenland National Park. However, polar bear hunting is permitted within the protected areas on Greenland.

Norway: About 56 per cent of the area of Svalbard is protected as either national park or nature reserve. This protection was not established specifically to benefit polar bears but protecting polar bear habitat was an important factor when these designations were made in the 1970s.

The islands of Kong Karls Land in Svalbard's northeast archipelago is protected as strict nature reserve and some of the most important denning areas for the Barents Sea population are found here. The area is closed to the public and highly restricted even for research and government patrolling.

Russia: Wrangel Island and Herald Island are the only areas in Russia protected as strict nature reserves to preserve important polar bear denning areas. Enforcement of this protection has, however, been lacking, and the scale of local hunting is not known.

Other protected areas in northern Russia overlap polar bear habitat, but were not established with this in mind. Monitoring and enforcement in most of these protected areas has also been weak due to serious financial constraints, particularly in recent years.

Conservation Challenges and WWF Priorities

A key element of WWF's mission is to preserve biodiversity for future generations. To achieve this, large tracts comprising entire intact ecosystems must be managed on a sustainable long-term basis, and global trends threatening these ecosystems, such as human-induced climate change and the emission of POPs and heavy metals, must also be halted or reversed.

As the polar bear is a keystone species at the top of the food web in the arctic seas, which include some of the world's most productive marine ecosystems, it is a good indicator of the overall status of these ecosystems (Eisenberg 1980). Successful conservation of polar bears and their habitats can thus have positive effects on many other species, in several key ecoregions, as well as on local human communities within the Arctic. Addressing the conservation of such keystone species therefore has a high priority within WWF.

Through its work in priority ecoregions, WWF is a driving force in the protection of large expanses of unfragmented land and marine areas to ensure that space-demanding species, such as the polar bear, can continue to roam undisturbed in intact ecosystems.

Through its toxics program WWF works at the global as well as the community level to reduce the production and transportation of persistent organic pollutants and other contaminants that threaten the health and condition of polar bears.

And finally, as part of its climate change program, WWF has targeted the polar bear as a unique symbol of the complexities and inter-dependencies of the arctic marine ecosystem. The WWF Climate Change Campaign, through its Arctic Climate Change Focal Project, currently supports leading scientists in their efforts to study and monitor the effects of climate change on polar bears and the arctic marine environment in which they live.

Conclusions

Polar bears are the last remaining large terrestrial carnivore found throughout most of its original range, and in numbers similar to those of pre-industrial development. Most of the original habitat of the polar bear is still intact, although not legally protected, and much of the range occupied by the species is uninhabited by humans. From a management perspective the polar bear is thus in quite a unique and positive situation.

There are, however, serious environmental threats facing this species. These include large-scale habitat fragmentation, excessive hunting, pollution, and climate change. Though the over-harvesting of certain populations is currently the most urgent threat to bears in some areas, the IUCN Polar Bear Specialist Group considers climate change to be one of the major conservation challenges for the overall polar bear population. In the resolutions from meetings of this group held in Nuuk, Greenland in June 2001, climate change is listed as the number one threat.

A warming trend has been observed over the arctic sea ice resulting in a three per cent decrease of sea ice extent per decade since the 1970s and more melt days per summer. This trend is expected to continue. Computer models suggest that with a doubling of CO_2 in the atmosphere the ice-free season will grow from 60 days to 150 days.
As the time bears have on the ice to hunt is cut short their opportunities for developing fat reserves to survive a longer ice-free season are more limited.

There is evidence that climate change is already affecting the condition of polar bears in the Hudson Bay area of Canada. Female bears are in poorer condition going into the denning period, suggesting difficulties obtaining sufficient food while hunting on the sea ice. These observations are indicative of what can be expected throughout the polar bear distribution in the future.

The combined effects of climate change are expected to negatively impact polar bear reproductive success, and thus lead to a decline in the overall population. These effects must also be seen in the context of other pressures facing this species, including unsustainable hunting practices and contamination by persistent organic pollutants.

Appendix: National Polar Bear Management

Each polar bear nation has established its own regulations and conservation practices to ensure survival of the species.

United States/Alaska

In the United States, the U.S. Fish and Wildlife Service is responsible for management and conservation of polar bears under the terms of the Marine Mammals Protection Act (MMPA) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). In 1972, the MMPA introduced a general ban on the taking of polar bears, however, harvest is allowed under specific conditions. Alaska Natives, for example, may harvest polar bears for subsistence, and for traditional handicraft and clothing. There are no quotas, but total harvest is monitored to ensure that it is within optimum sustainable levels.

In the northeast, Alaska shares its polar bear population with Canada. An agreement between indigenous groups of Alaska and Canada[3] ensures that the Beaufort Sea population is harvested and managed sustainably.

In October 2000 the governments of the United States and the Russian Federation signed the *Agreement on the Conservation and Management of the Alaska-Chukotka Polar Bear Population.* This agreement supports management of polar bears shared between the U.S. and Russia, by entering into law many of the provisions from the International Polar Bear Agreement. It requires enactment of enabling legislation by the U.S. Congress and other steps by Russia before it has the force of law. The US is expected to adopt such legislation in the spring 2002 session of Congress.

Canada

Apart from complying with the CITES, Canada's federal government has delegated the authority for the management of polar bears to its provinces and territories, some of which now share the responsibility with co-management boards through the settlement of land claims.

The harvest of polar bears is permitted in Canada, in accordance with the International Polar Bear Agreement, under various quota systems for aboriginal groups; quotas are not set in Quebec and Ontario. Hunting licenses issued from the quotas can be sold, for example to non-aboriginal sport hunters. The trade of skins, meat, and other polar bear products is regulated under CITES.

In the Northwest Territories and the Nunavut Territory, co-management agreements between jurisdictions with shared populations have been developed. Some of these include flexible quota systems to ensure that harvesting is sustainable.

The close cooperation among jurisdictions, co-management boards and other interested parties developed in recent years has resulted in polar bears being among the better managed species in Canada.

Greenland

In Greenland, polar bear hunting and management regulations are administered by the Greenland Home Rule Government. These regulations state that polar bears can only be taken by native hunters who hunt and/or fish as a full time occupation, and who have a valid hunting license. These regulations are intended to limit the take of polar bears to Inuit subsistence hunters.

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[3] The North Slope Borough and Inuvialuit Game Council Hunter Management Agreement

There are no hunting quotas in Greenland, however, reporting and monitoring systems are under development. These systems are not yet fully functional, and there has been international concern for a number of years that the Greenlandic polar bear harvest was unsustainable. This has caused particular concern in areas where the populations are shared with neighbouring countries: Canada in the west and Norway in the east.

In November 2000, the Greenland Home Rule Government decided in principle to work toward the introduction of quotas in the catch of polar bears and to introduce other catch-regulating mechanisms. The Greenland Home Rule Government and the Government of Nunavut (Canada) continue to discuss the establishment of a memorandum of understanding between Canada and Greenland regarding the co-management of the polar bear populations they share.

As there is no current quota system based on sound population estimates in Greenland, there is also no centrally organized licensing for sport hunting.

Norway

Polar bear management in Norway is the responsibility of the Directorate of Nature Management, which is under the Norwegian Ministry of the Environment. Day-to-day decisions regarding culling or handling of problem bears are delegated to the Governor of Svalbard.

In Norway, polar bears have been protected since 1973 with the following exceptions: killing in self-defence, protection of property, and mercy-kills. The Barents Sea polar bear population is thus the only population that can be said to be truly without impacts from harvesting. There are no indigenous communities on Svalbard that can claim traditional harvesting rights. The primary human influence on polar bears on these islands is through the large and growing tourist industry. All persons travelling on Svalbard are encouraged to carry appropriate firearms for protection against polar bear attack. As tourist numbers rise, human-bear conflicts are expected to follow.

Russia

Management of polar bears in Russia is the responsibility of the Main Administration of Biological Resources under the Ministry of Natural Resources of the Russian Federation. Regional committees are responsible for management at the local level.

A federal ban on all polar bear hunting was introduced in 1956. There has, however, been no monitoring of incidental kills of polar bears since then, and there is concern for widespread poaching. The general lack of law-enforcement and Russia’s economic decline has allowed poaching to increase, however, the dismantling of military installations and abandonment of related settlements has had a counter-balancing effect.

In the early 1990s, indigenous communities in Chukotka applied for harvesting rights, as polar bears have always been an important part of their subsistence and local tradition. The *Agreement on the Conservation and Management of the Alaska-Chukotka Polar Bear Population* signed by the United States and the Russian Federation in October, 2000 introduces legal harvesting of polar bears for indigenous people in the Chukotka region. The agreement has the potential to create better population estimates, and better management arrangements, and thus to ensure in the longer term, sustainable polar bear populations in the region.

Abbreviations Used in the Report

CITES The Convention on International Trade in Endangered Species, an international agreement between governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival. On the web at www.cites.org.

CO_2 Carbon Dioxide

DDT A colourless, odourless, water-insoluble crystalline insecticide—C14H9Cl5—that tends to accumulate in ecosystems and has toxic effects on many vertebrates.

FWS The United States Fish and Wildlife Service. On the web at www.fws.gov.

HCB Hexachlorobenzene, a synthetic organochlorine pesticide also used as an industrial chemical.

HCH Hexachlorocyclohexanes, a group of synthetic organochlorine compounds mostly used as pesticides.

IgG A class of immunoglobolin that includes the most common antibodies circulating in the blood

IPCC The Intergovernmental Panel on Climate Change, an international organisation initiated by the World Meteorological Union and United Nations Environmental Programme to assess the scientific, technical and socio-economic information relevant for the understanding of the risk of human-induced climate change. On the web at www.ipcc.ch.

IUCN The International Union for the Conservation of Nature an international, an international, intergovernmental organization whose mission is to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable. On the web at www.iucn.org.

MMPA The Marine Mammal Protection Act, a domestic act for protection of marine mammals within the waters of the United States of America.

PBSG The Polar Bear Specialist Group, a specialist group within the IUCN/SSC network. On the web ate pbsg.npolar.no.

PCB polychlorinated biphenyl, any of several compounds that are produced by replacing hydrogen atoms in biphenyl with chlorine, have various industrial applications, and are poisonous environmental pollutants which tend to accumulate in animal tissues.

PFOS Perfluorooctane sulfonate, a group of compounds containing fluorocarbons.

POPs Persistent Organic Pollutants.

SSC The Species Survival Commission, a knowledge network within the IUCN of volunteer members working as wildlife researchers, government officials, wildlife veterinarians, zoo employees, marine biologists, wildlife park managers, and experts on birds, mammals, fish, amphibians, reptiles, plants, and invertebrates. On the web at www.iucn.org/themes/ssc.

WWF The World Wide Fund for Nature. In the USA and Canada, WWF continues to be known as the World Wildlife Fund. On the web at www.panda.org.

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