NATURAL RESOURCES DEFENSE COUNCIL

Via Electronic and Overnight Mail

April 9th, 2007

Dr. Rosa Meehan, Supervisor
U.S. Fish and Wildlife Service
Marine Mammals Management Office
1011 East Tudor Road
Anchorage, AK 99503
Tel: 907/786–3800

Dear Dr. Meehan:

Re: Comments on Proposed Rule to List the Polar Bear as a Threatened Species

On behalf of the Natural Resources Defense Council ("NRDC") and our over 650,000 members, we submit the following comments on the U.S. Fish and Wildlife Service's ("Service") proposal to list the polar bear as a threatened species throughout its range. See "Proposed Rule To List the Polar Bear (*Ursus maritimus*) as Threatened Throughout Its Range," 72 Fed. Reg. 1064 (Jan. 9, 2007) ("Proposed Rule").[1]

As a general matter, NRDC strongly supports the Proposed Rule and applauds the Service for recognizing that polar bears are threatened with extinction in the foreseeable future and throughout their range. Indeed, in the three months since the Service issued its rule, the soundness of this conclusion has only been bolstered by the available scientific evidence. Nonetheless, we believe that the proposed rule suffers from a number of defects and could be significantly improved. In particular, the proposed rule needs to incorporate a different, and much longer-term, definition of "foreseeable future"; should revise its assessment of the potential threat posed by oil and gas and other activities; and should include a proposed designation of critical habitat, at least for some populations. Finally, and perhaps most significantly, the Proposed Rule should explicitly acknowledge the cause of the central threat to the polar bear that it identifies: disappearing sea ice. It is only by recognizing that reduction in sea ice extent is being driven by anthropogenic greenhouse gas emissions that the Service can begin to grapple with ways to combat this threat, as the Endangered Species Act requires.

[1] NRDC also incorporates by reference the comments submitted by the Center for Biological Diversity and Greenpeace, Inc., and by Earthjustice.

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I. THE PROPOSED RULE SHOULD REVISE ITS DEFINITION OF "FORESEEABLE FUTURE"

The Endangered Species Act ("ESA" or "Act") defines a threatened species as "any species which is likely to become an endangered species *within the foreseeable future* throughout all or a significant portion of its range." 16 U.S.C. § 1532(20) (emphasis added). However, neither the Act nor any regulation promulgated by the Service defines the term "foreseeable future." For the purposes of the Proposed Rule, the Service defines foreseeable future as a period extending 45 years into the future. 72 Fed. Reg. at 1070. Although polar bears are likely to become endangered within 45 years, this time period is too short. Among other things, the choice of 45 years is not legally justified, does not comport with the best available science, and is inconsistent with previous agency action.

The Service justifies its proposed definition of foreseeable future in the Proposed Rule as follows:

> The [Polar Bear Specialists Group], when they reassessed the status of polar bears globally in June 2005, used the criteria described in the IUCN/SSC Red List process (IUCN 2004) to determine which Red List category the polar bear should be assigned. The criteria, used for all species that IUCN assesses in the Red List process, use observed, estimated, inferred or suspected population size reductions of a certain percentage over the last 10 years or three generations, whichever is the longer to categorize species. A generation, as defined by IUCN, is calculated as the age of sexual maturity (5 years) plus 50 percent of the length of the lifetime reproductive period (20 years). Based on these calculations, the projected length of 1 generation for a polar bear was calculated at 15 years, and the projected period for 3 generations was calculated as 45 years.

<u>Id.</u>

While it is true that the IUCN's classification of the polar bear as "vulnerable," defined as a species "facing a high risk of extinction in the wild," was adopted based on a 3 generation (or 45 year) time frame, it is important to note that the IUCN's criteria themselves contemplate that population projections may be made for taxa up to 100 years into the future. IUCN (2001).

Moreover, unlike the Endangered Species Act, the IUCN's criteria do not call for listings to be based on a standard of foreseeablity. Thus, the IUCN's use of percentage declines over a given generational period—while certainly helpful when determining whether a species should be listed under ESA—cannot be used to limit what the phrase "foreseeable future" means. Rather, when interpreting this phrase, the Service is bound by the normal rules of statutory construction that apply under United States law. First and foremost among those rules is that statutory language should normally be construed consistent with its plain and ordinary meaning.[2]

The ordinary meaning of "foreseeable" is something that is reasonably predictable. Thus, Merriam-Webster's Online Dictionary defines "foreseeable" as something "as may be reasonably anticipated" or "within the range for which forecasts are possible." Similarly, Black's Law Dictionary defines "forseeability" as "[t]he quality of being reasonably anticipatable."

This view of foreseeability is bolstered by the Endangered Species Act's statutory scheme as a whole. Central to the Act is the requirement that decisions to list species as either endangered or threatened be made "solely" on the basis of the best available scientific and commercial data. 16 U.S.C. § 1531(b)(1)(A). This requirement to use the best available science as the basis for all listing determinations applies with equal force to the Service's determination of what constitutes the "foreseeable future" for any particular species. Thus, if—based on the best available science—the Service reasonably anticipates that a species may become endangered within a specific timeframe it must list that species as threatened. In this case, the best available science strongly militates towards a timeframe of at least 100 years.

As an initial matter, a 100 year time frame is normally used to analyze population viability of bear species—in particular the polar bear's closest relative, the brown bear.[3] Second, and as set forth in more detail below, the primary threat identified by the Proposed Rule, the disappearance of Arctic sea ice, is based on climate models and projections nearly all of which rely on 100 year projections. See Part II, infra. Thus, the best available science as identified by the Service in the Proposed Rule shows that the principal threat to the polar bear can be reasonably anticipated through the end of this century. Finally, the Service's selection of a 45 year time frame has consequences. Although the Service has determined (correctly) even based on this shorter period that polar bear populations are threatened with extinction, artificially cutting off its projections of threats at the 45 year mark actually underestimates the extent of probable sea ice loss as shown by some models.

This can be readily seen by examining *Figure 1*, below. *Figure 1* shows projections of September sea ice extent based on six different model runs. Each run shows declining sea ice through the end of the century. However, separate runs show varying levels of decline at different times. Significantly, some of these declines (those in Runs 2 and 4, for example) show additional drops in sea ice extent around, or just after, 2060. By choosing a 45 year timeframe, the Service might ignore the predictable impact of this sea ice loss.

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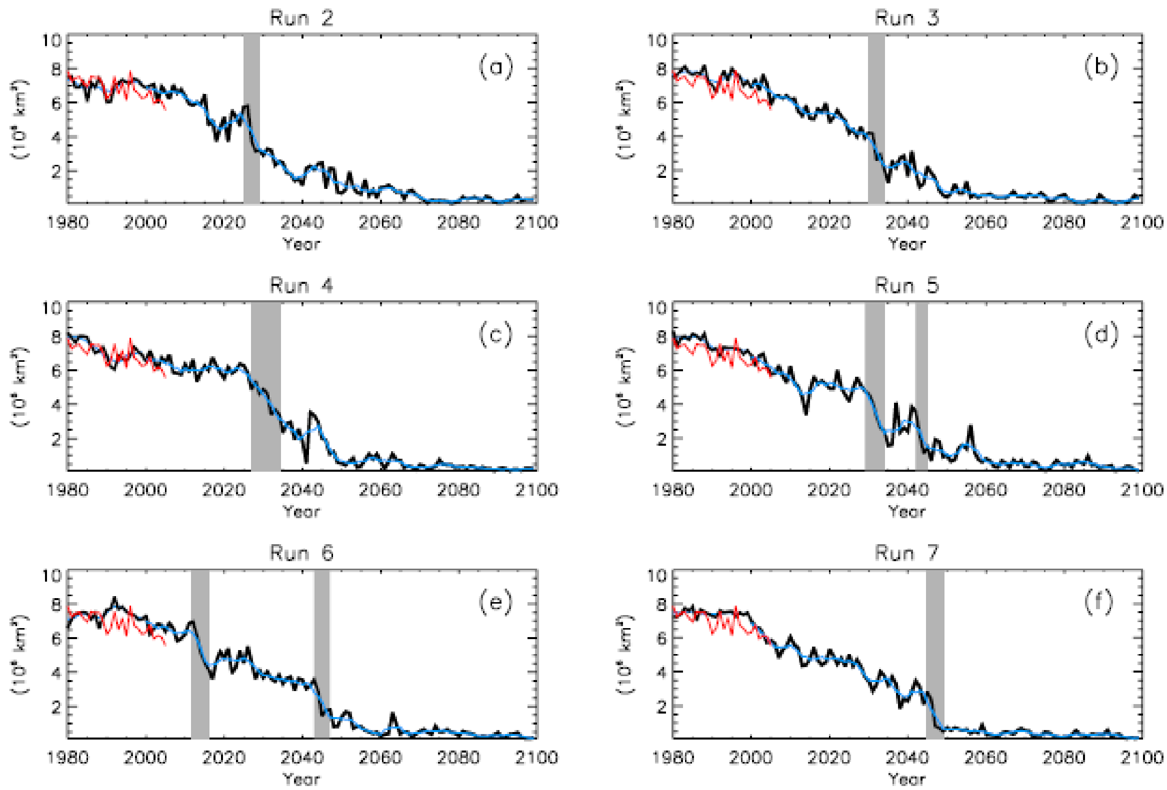
[2] See, e.g., Safe Air v. Meyer, 373 F.3d 1035, 1041 (9th Cir. 2004) ("words will be interpreted as taking their ordinary, contemporary, common meaning")

[3] Shaffer (1978); Dennis *et al*. (1991); Saether *et al*. (1998); Wiegand *et al*. (1998). See also Allendorf and Ryman (2002) (noting that "consideration of genetic effects over time frames beyond 100 years is also important for the long-term viability of populations and species.")

Figure 1. The Northern Hemisphere September ice extent from six additional CCSM3 A1B ensemble members. The five-year running mean (blue) and observed extent (red) are also shown. Grey shading indicates an abrupt transition as defined in the text. (Holland et al 2006)



The Service should take into account the full extent of reasonably anticipated sea ice declines, not just those declines that are projected for the next 45 years.

Nor would it be unusual for the Service to use a 100 year time frame to evaluate current threats to the polar bear. In addition to being supported by the best available scientific data, the Service has a long history of using 100 year periods in listing decisions. As the Proposed Rule itself notes, the Service adopted a 100 year definition of "foreseeable future" when analyzing threats to the greater sage grouse. 72 Fed. Reg. at 1070. Similarly, the National Marine Fisheries Service ("NMFS") uses 100 year time frames when examining the status of marine mammals under the Endangered Species Act. Thus, when NMFS reclassified the stellar sea lion into two distinct populations, it employed 100 year models to assess the threats to those populations. See "Change in Listing Status of Steller Sea Lions Under the Endangered Species Act," 72 Fed. Reg. 24345, 24346 (May 5, 1997).

Although polar bears are threatened with extinction over the next 45 years, the best available science allows—and the Endangered Species Act requires—the Service to reasonably project threats to the species at least through 2100. The Proposed Rule should be revised to reflect this timeframe and the threats to the polar bear reevaluated on this basis.

II. Global Warming Remains the Principal Threat to the Survival of Polar Bears in the Wild

A. The Best Available Science Indicates that Global Warming Is Anthropogenic in Origin and is Accelerating

After the Fish and Wildlife Service published its Proposed Rule, the Intergovernmental Panel on Climate Change (IPCC) completed the first section of its Fourth Assessment Report. The Summary for Policymakers was adopted by consensus and released on February 2, 2007. The report states with a high degree of certainty that global warming is happening now and is human-caused. It finds that “warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level.”[4]

Since the Industrial Revolution, the concentration of carbon-dioxide in the atmosphere, the primary gas responsible for global warming, has increased from 280 parts per million (ppm) to over 380 ppm today. Associated with this rise in heat-trapping gases is a rise in globally-averaged temperatures of 0.8ºC.[5] This warming trend has accelerated in the last several decades, with an average warming rate of 0.13 ºC per decade for the last 50 years, or nearly twice the rate for the last century.[6] Instrumental records and reconstructions of past temperature from temperature-sensitive proxies, such as tree rings, ice cores and coral reefs indicate that the globally-averaged surface temperature is now “very likely” (greater than 90 percent probability) higher than at any time in the last 500 years and “likely” (greater than 66 percent probability) higher than it has been in the last 1,300 years.[7] The spatial extent of recent warming is of a greater significance than other periods of warmth.[8]

The ten warmest years on record have all occurred since 1990, solidifying the extent of warming during the 20th Century. Indeed, eleven of the last twelve years are among the twelve warmest years in air temperature records dating back to 1850.[9] This trend includes 2005, which tied with 1998 for the hottest year on record according to NASA.[10] Record warmth in 2005 is particularly significant as global temperatures in 1998 received a boost of up to 0.2ºC from El Niño. No such large scale ocean-atmospheric phenomenon occurred in 2005. The main reason for the high globally-averaged temperature in 2005 was a large positive anomaly in the Arctic (*Figure 2*), supporting evidence that the record warmth was primarily caused by a build-up of anthropogenic greenhouse gases in the atmosphere.

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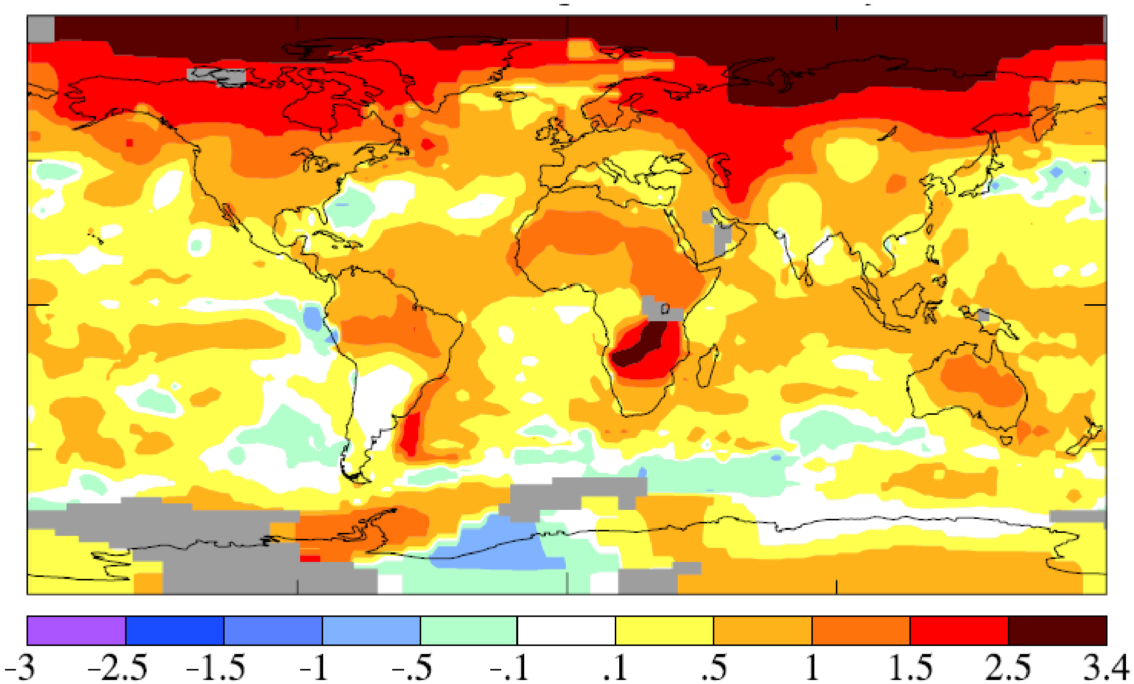
[4] IPCC (2007)
[5] Hansen *et al*. (2006)
[6] IPCC (2007)
[7] *Ibid*
[8] Osborn and Briffa (2006)
[9] IPCC 2007
[10] Hansen *et al*. (2006)

Figure 2: 2005 surface temperature anomaly (˚C) (Hansen *et al*. 2006)



Equally significant, "observations since 1961 show that the average temperature of the global ocean has increased to depths of at least 3000 m and that the ocean has been absorbing more than 80 percent of the heat added to the climate system."[11] These ocean observations are a direct confirmation that the earth's energy balance has changed, with the earth consistently absorbing more energy from the sun than it emits back into space. The increase in heat-trapping gases in the atmosphere is the only plausible explanation.

Since the late 19th Century, about 500 billion metric tons of CO_2 have been emitted into the atmosphere with the current global emissions at over 30 billion metric tons of CO_2 per year.[12] The U.S. is responsible for about 20 percent of global greenhouse gas emissions, although we are responsible for less than 5 percent of global population.

An additional worrying trend is that not only are CO_2 emissions rising, but they are accumulating in the atmosphere at a greater rate than in the past. In 2005 and 2006 the concentration of CO_2 in the atmosphere increased by 2.53 ppm and 2.34 ppm, respectively, adding to the recent trend of increases in atmospheric CO_2 of over 2 ppm per year.[13] For the last decade the CO_2 concentration growth rate was 1.9 ppm per year, significantly faster than the average growth rate since continuous monitoring began in 1958.[14] As emissions continue to rise and greenhouse gases continue to accumulate in the atmosphere, we can expect further warming across the globe with the associated

[11] IPCC (2007)
[12] U.S. Department of Energy (2005); IPCC (2007)
[13] Tans (2006)
[14] IPCC (2007)

impacts, including changes in the frequency and intensity of precipitation, sea-level rise, heatwaves, droughts and windstorms, also increasing in the future.

B. Global Warming's Effects in the Artic are Particularly Acute

As a general matter, the Proposed Rule provides an excellent review and summary of observed trends in Arctic temperatures, precipitation, and sea ice extent. It is important that the Proposed Rule focuses on the Arctic's warming trend because there is much spatial variability around the globe and, while the globally averaged temperature has increased by 0.8ºC, the "average arctic temperatures increased at almost twice the global average rate in the past 100 years."[15]

In particular, the Service rightly relies on the authoritative findings of the Arctic Climate Impact Assessment (ACIA 2005), the National Snow and Ice Data Center (NSIDC), and the IPCC. Although, as noted by the Proposed Rule, there is significant inter-annual variability in sea ice extent, these reviews document clear declining trends in the extent of annual average sea ice (2.7 percent per decade), late summer sea ice (7.7 percent per decade), and perennial sea ice (9.8 percent per decade).

The best available science shows that these trends are likely to accelerate along with global warming if heat-trapping emissions are not curtailed. As noted in the Proposed Rule, the powerful ice-albedo (surface reflectivity) positive feedback mechanism will continue to amplify arctic warming compared to the global average, 72 Fed. Reg. at 1071, rendering Arctic sea ice particularly vulnerable to the effects of global warming. By the latter part of the 21st Century, Arctic annual average temperatures are predicted to increase by roughly 3 to 5ºC over land areas and by up to 7ºC over the oceans.[16]

1. <u>Arctic warming over the past century</u>

Increasing temperatures, reductions in sea ice extent and thickness, thawing permafrost and melting glaciers all provide evidence for recent warming in the Arctic. Although regional variations exist, the Arctic as a whole has exhibited a clear warming trend over the last century. This trend tends to be amplified in the winter with larger increases in temperature than the summer. For example, Alaska and western Canada have experienced a 3 to 4ºC increase in winter temperatures over the past 50 years.[17]

Precipitation has also increased over the past 100 years, and this increase has primarily been seen as an increase in rain rather than snow. Observations suggest that total precipitation has increased by 8 percent over the past century.[18]

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[15] IPCC (2007). Evidence suggests that the reason why warming in the Arctic is more intense than the global average is due to the combined effect of greenhouse gas concentrations and other aerosol pollutants, such as sulfates, nitrates and ozone. Lubin and Vogelmann (2006); American Meteorological Society Environmental Science Seminar Series (2006). Enhanced aerosol conditions due to industrial pollution from Eurasia and the Americas may alter the properties of Arctic clouds which, in turn, trap more longwave radiation close to the Earth and contribute to Arctic warming.
[16] ACIA (2004); Anisimov and Fitzharris (2001).
[17] ACIA (2004)
[18] *Ibid*

Another key indicator of climate change in the Arctic is sea ice. Sea ice (and particularly summer sea ice) plays an extremely important role in the Arctic's ecosystem by providing an important habitat for both "ice dependant" and "ice loving" species. Sea ice's role is equally important in the climate feedback mechanisms of the Arctic, and changes in sea ice extent can impact the Arctic's albedo, cloudiness, humidity, ocean circulation patterns and the exchange of heat and moisture at the ocean surface. As warming continues, the extent of sea ice and the albedo of the Arctic surface will decrease (as ice transitions to ocean which better absorbs solar energy) and therefore cause additional heating at the surface. This positive feedback will further reduce sea ice cover as the cycle intensifies.

Recent analysis by the IPCC confirms that annual average Arctic sea ice extent has declined by 2.7 percent per decade since 1978, with a decline of over 7 percent per decade in summer.[19] Declines in sea ice extent have also been consistently reported by the National Snow and Ice Data Center (NSIDC).

As the Proposed Rule notes, in September 2005, the NSIDC released their calculations of sea ice extent at the summertime minimum for 2005. 72 Fed. Reg. at 1071. The five-day running mean for sea ice extent (the area of ocean that is covered by at least 15 percent ice) was 2.05 million square miles. This is the lowest sea ice extent ever observed since the start of the satellite record in 1979 and reflects a decline in sea ice of approximately 8 percent per decade, and a total decline of approximately 500,000 square miles, an area about twice the size of Texas. Not only does 2005 represent an all-time low in sea ice extent, but with 2006 (2.2 million square mile) it continues a trend in summertime sea ice extent decline with five out of the six lowest years of sea ice extent occurring since 2002.[20]

Record declines in winter sea ice extent were also recorded in 2005, at 5.72 million square miles, and continued in 2006, with March 2006 again recording the lowest winter sea ice extent on record (5.6 million square miles) (*Figure 3*).[21] Results for March 2007 were comparable, with NSIDC reporting a March sea ice extent of 5.7 million square miles.[22]

While the long-term mean March sea ice extent is 6.06 million square miles, 2005 and 2006 set two new record lows, and 2007 just barley missed this mark. These trends are particularly significant, illustrating that for three years running Arctic sea ice has failed to recover to its full extent during the winter months. This decline in wintertime sea ice extent below the long-term average is approximately equivalent to a loss of sea ice three times the area of California.

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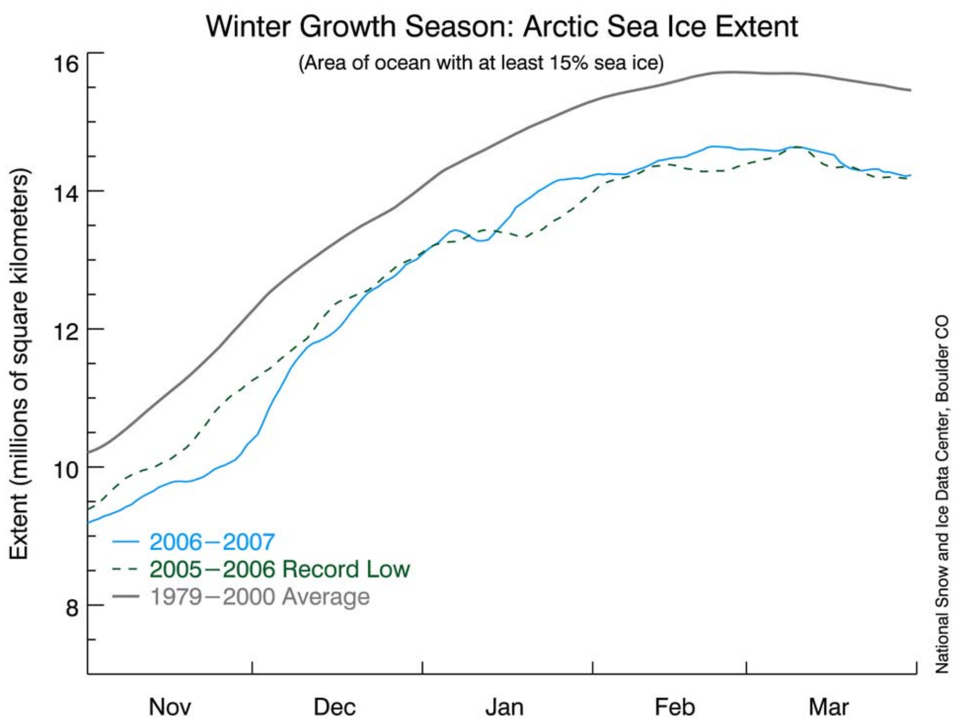
[19] IPCC (2007)
[20] Stroeve *et al*. (2005) and NSIDC, NASA; University of Washington (2005); Serreze *et al.*, (2007)
[21] NSIDC (2006)
[22] NSIDC (2007)

Figure 3. Winter Arctic Sea Ice Extent. NSIDC (2007)



Cooler winter temperatures generally allow sea ice to "rebound" after summertime melting. Low winter sea ice extent means that the ice is freezing later in the fall and growing at a slower pace during the winter. In fact, the wintertime trend is alone responsible for almost a 3 percent decline in sea ice extent per decade.[23]

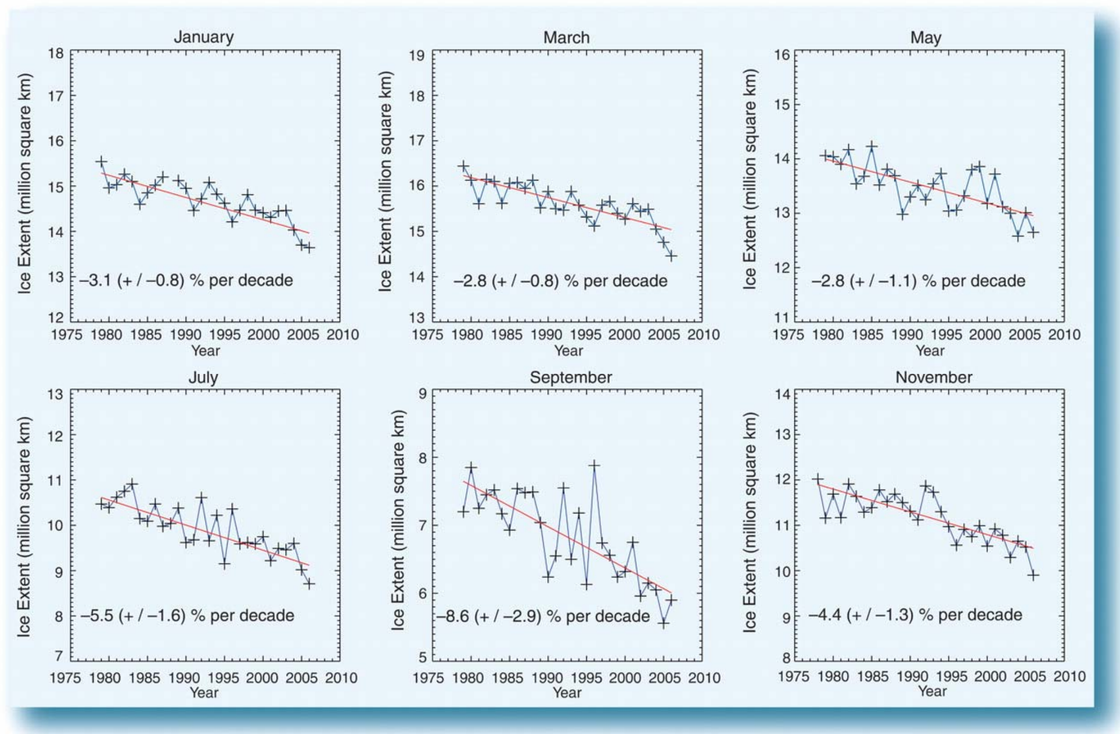
Additionally, over the satellite record, the length of the melt season has increased by 13.1 days per decade in sea ice areas.[24] This trend can be seen in the 2005 melt season which started 17 days prior to the mean melt onset date.[25] As explained below, this later freeze-up is of particular significance to the polar bear, as extended melting seasons equate to longer fasting periods for polar bears and, in turn, negatively impacts the species reproductive capability.[26]

Serreze, Holland, and Stroeve review arctic sea ice trends and projections in the March 16, 2007 issue of *Science*'s special section on polar science. They find that from 1979 to 2006 Arctic sea ice extent declined for every month, with the largest rate of 8.6 ± 2.9 percent per decade in September (*Figure 4*). While acknowledging considerable natural variability in Arctic climate and sea ice conditions, they conclude that "[t]his ice loss is best viewed as a combination of strong natural variability in the coupled ice-

[23] Meier *et al*. (2005)
[24] Comiso (2005)
[25] NSIDC, NASA and University of Washington (2005)
[26] Derocher *et al.* (2004)

ocean-atmosphere system and a growing radiative forcing associated with rising concentrations of atmospheric greenhouse gases…"[27]

Figure 4: Monthly sea ice extent, 1979 - 2006 (Serreze et al., 2007)



An examination of temperature records from a few individual weather stations, such as Churchill and Frobisher Bay, in no way invalidates this conclusion, as some authors have implied.[28] First, Arctic sea ice extent is a function of regional climate, not localized temperature. As noted above, the IPCC concludes that the Arctic as a whole is warming at a rate almost twice as fast as the globe as a whole. Second, the effects of natural variability, which are acknowledged by Serreze et al. and the IPCC, are much greater when examining individual weather station records, rather than regional averages.

2. Projected Arctic warming over the 21st Century

Future warming is projected with global climate models (GCMs) by specifying scenarios for natural (solar and volcanic) and anthropogenic (greenhouse gas emissions) forcing mechanisms. GCMs approximate the various processes of the climate system and generate projections of how our climate might change in the future. The Intergovernmental Panel on Climate Change (IPCC) produced a Special Report on Emission Scenarios (SRES) which developed multiple scenarios based on future changes in global emissions due to population, economic growth, technological and

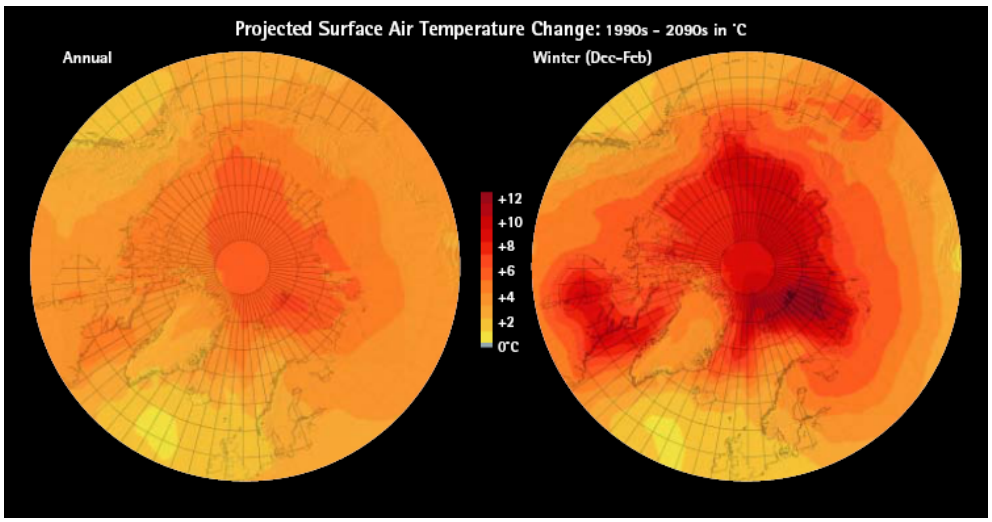
[27] Serreze *et al* (2007).
[28] E.g., Dyck *et al.* (2007). See also peer review critique of article from *Oikos* (enclosed).

political change and other aspects of future society. Most projections of future climate change are calculated from this range of scenarios.

Based on five GCMs and the B2 emissions scenario,[29] the ACIA (2004) finds that towards the end of this century, annual average temperatures are projected to rise across the entire Arctic and at a much higher magnitude than the global average. The largest amount of Arctic warming is seen in winter temperatures which show increases of 4 to 7ºC over the land and 7 to 10ºC over the oceans (*Figure 5*).

This increase in temperature is expected to be accompanied by increased precipitation due to an intensification of the hydrological cycle. The total annual precipitation for the entire Arctic is projected to increase by approximately 20 percent by 2100.[30] Most of this increase will be as rain, rather than snow, and it is also projected to occur mostly over coastal regions in the winter and fall.

Figure 5: Projected surface air temperature changes over the 21st Century (ACIA, 2004)



Some research suggests current climate models may actually *underestimate* global warming projections because of their failure to account for positive feedbacks such as increased greenhouse gases concentrations in response to global warming,[31] polar stratospheric clouds,[32] and hurricane-induced ocean mixing.[33] As such, it is entirely plausible that current climate models underestimate the extent of warming in the Arctic region and the extent and rate of sea ice decline.

Torn and Harte (2006) quantified the positive feedback associated with carbon-dioxide and methane, the two primary anthropogenic greenhouse gases, and found that the warming associated with doubling of carbon dioxide due to human activities is

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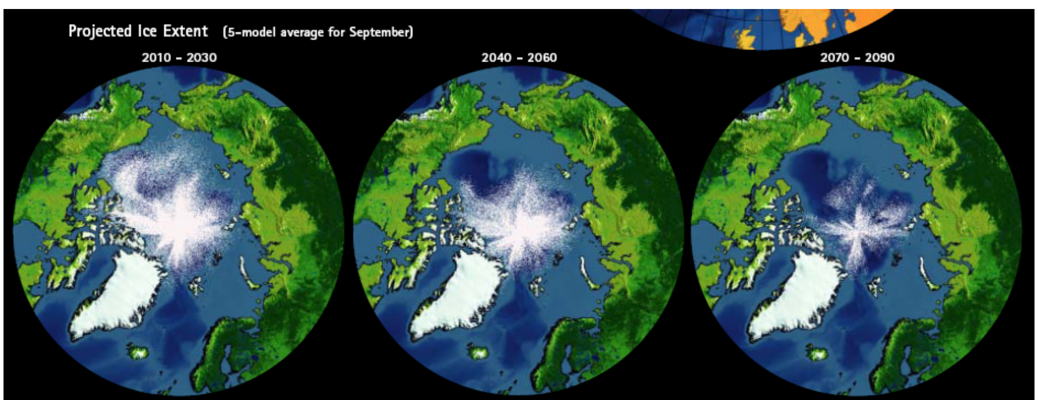
[29] The B2 emissions scenario results in a temperature rise slightly below the middle of the range for SRES.
[30] ACIA (2004)
[31] Torn and Harte (2006); Scheffer *et al.* (2006)
[32] Sluijs *et al.* (2006)
[33] *Ibid*

amplified from the range of 1.5 – 4.5˚C to 1.6 – 6.0˚C. Similarly, Scheffer *et al.* (2006) find that by incorporating the positive feedback associated with higher global temperatures promoting greenhouse gas levels, the century-scale feedback of atmospheric carbon-dioxide will enhance warming by an extra 15 to 78 percent.

Changes in temperature over the Arctic will have a large impact on sea ice because the ice-albedo feedback effect together with increased heat exchange between the open ocean and the atmosphere, discussed above, have been shown to be the primary mechanism of climate forcing in the Arctic. Increasing temperatures could result in additional declines of 10 to 50 percent in annual average sea ice extent projected by 2100. Summer sea ice extent is projected to be even more severely impacted by Arctic warming and the ACIA five-model average projects a decline of more than 50 percent, with some models showing a complete disappearance of summertime sea ice extent. This rapid decline in sea ice extent is manifested through the positive feedback mechanism of sea ice melting decreasing surface reflectivity. *Figure 6* illustrates the potential decline in summertime minimum sea ice extent over the next century. The marked decrease, to near-total disappearance, in sea ice is potentially devastating for the polar bear.

Figure 6: Projected sea ice extent decline over the 21st century (ACIA, 2004)



September sea-ice extent, already declining markedly, is projected to decline even more rapidly in the future. The three images above show the average of the projections from five climate models for three future time periods. As the century progresses, sea ice moves further and further from the coasts of arctic land masses, retreating to the central Arctic Ocean. Some models project the nearly complete loss of summer sea ice in this century.

Assuming no curbs on emissions of heat-trapping gases, the IPCC projects that Arctic sea ice will continue to shrink and notes that, "[i]n some projections, Arctic late-summer sea ice disappears almost entirely by the latter part of the 21st century, a state that has not occurred over at least the last million years."[34] Indeed, Holland, *et al.* (2006) conclude that under some circumstance the Arctic could reach "near ice-free September conditions by 2040."

The potential for dramatic Arctic warming is bolstered by research that shows that 55 million years ago, during Palaeocene/Eocene thermal maximum ("PETM"), the Arctic region resembled the climate of Florida.[35] Although greenhouse gas concentrations were much higher in the PETM, the paleoclimate record collected and

[34] IPCC (2007); Overpeck *et al*. (2005)
[35] Moran *et al.* (2006); Sluijs *et al.* (2006); Brinkhuis *et al.* (2006)

reconstructed by the Arctic Coring Expedition illustrates that the Arctic is capable of warming to over 23˚C and being completely ice-free. While such drastic warming is not expected during the next century—the absolute polar temperatures derived for the PETM are more than 10˚C warmer than those predicted by current climate models[36]—the existence of the PETM once again illustrates that scientists may not have fully accounted for all positive feedbacks, such as polar stratospheric clouds or hurricane-induced ocean mixing.[37]

In short, if global warming is unchecked the Arctic is likely to enter a "super-interglacial" during this Century, with conditions far warmer and more ice-free than those that occurred during the so-called Holocene climate optimum some 6000 years ago or the Eemian interglacial around 120,000 years ago. This would represent a far warmer climate than polar bears have ever experienced.

The best available science clearly shows that it is very likely that Arctic sea ice will continue to decline, and at an accelerated rate, if global warming pollution is not reduced. While the full extent of this decline is not know, all indications point to a unprecedented decline that could leave the Arctic ice free in the summer as soon as the middle of the Twenty-First Century.

C. The Proposed Rule Should Account for the Effect of Management Decisions on Future Sea Ice Extent and Revise its Discussion of Existing Regulatory Mechanisms

Although the Service accurately summarizes the best available science regarding observed trends in Arctic sea ice and correctly notes that all climate "models project continued Arctic warming and continued decreases in the Arctic sea ice cover in the 21st century due to increasing global temperatures," 72 Fed. Reg. at 1072, the Proposed Rule fails to address the causes of increasing global temperatures or forthrightly discuss the absence of existing regulatory mechanisms to control climate change. As a result, the Proposed Rule fails to recognize that the future of the polar bear will depend, in large part, on management decisions made by the United States and other governments regarding emissions of CO_2 and other heat-trapping gases.

On December 21, 2006, the Service finalized its Range-Wide Status Review of the Polar Bear ("Status Review").[38] The Status Review contains a detailed discussion of global warming and the threat it poses to the continued existence of the polar bear. In particular, the Status Review has a section on "Mechanisms to regulate climate change." Status Review at 136. This section, which reviews some international and domestic efforts to regulate greenhouse gas emissions, stands in stark contrast to the Proposed Rule, which fails to include any of this discussion, instead simply stating that "[t]here are no known regulatory mechanisms effectively addressing reductions in sea ice habitat at this time." 72 Fed. Reg. at 1086.

The Proposed Rule's cramped and artificial reference to regulatory mechanisms "addressing reductions in sea ice" is not useful. As all of the science in the Proposed

[36] Sluijs *et al.* (2006)
[37] *Ibid*
[38] Schliebe *et al*. (2006)

Rule acknowledges, and as the Status Review clearly discusses throughout its text, reductions in sea ice is caused by the anthropogenic release of greenhouse gases. Therefore, the correct analysis of existing regulatory mechanisms is not mechanisms to address "reductions in sea ice" but rather mechanisms to address global warming.

Correctly identifying and discussing the current lack of regulatory mechanisms—particularly in the United States—to effectively address global warming is important for two reasons. First, as a legal matter, the Service needs to justify its conclusion (which is sadly accurate) that currently no existing regulatory mechanism to adequately address global warming in the Arctic exists. Second, the scientific evidence is clear that regulatory mechanisms that effectively address greenhouse gas emissions would, if fact, be of enormous benefit to the polar bear.

For example, as discussed above, Holland *et al.* (2006), found that the Arctic could be ice-free in September within 30 to 50 years if greenhouse gas emissions follow the SRES A1B scenario, which is a "'middle of the road'" case with no policies to limit global warming (*Figure 1*, supra). Of note here is that, in these projections, sea ice does not decline at a constant rate, but rather exhibits abrupt transitions during which September sea ice declines about four times faster than during any five year interval in the observations. Reviewing a larger ensemble of projections from other climate models, Holland et al. find that the likelihood of seeing an abrupt reduction in September sea ice depends on the rate of increase in greenhouse gas concentrations. Abrupt transitions were seen in 3 of 15 model runs using a slower increase in greenhouse gases, 6 of 15 using the middle scenario, and 7 of 11 using a faster increase.[39]

Although these scenarios are all variations of business-as-usual projections and assume no policies to limit global warming pollution, they imply that the risk of abrupt reductions in Arctic sea ice can be reduced by curbing future greenhouse gas emissions. NRDC urges the Service to provide a fuller discussion of the causes of global warming. In particular, the Service should review the literature on the relationship between future greenhouse gas emissions and concentration levels and the projected rate of Arctic sea ice decline. Such a review would be an important foundation for developing an effective recovery plan for the polar bear and is necessary for a complete and accurate finding that polar bear habitat is threatened by melting Arctic sea ice.

Finally, the Proposed Rule fails to note that listing the polar bear under the Endangered Species Act will, in fact, provide polar bears with regulatory mechanisms to address the multitude of threats facing the species, including global warming. Listing the bear will require the designation of critical habitat, will compel the Service to prepare a polar bear recovery plan, and will subject federal actions, including those that increase the emissions of greenhouse gasses, to the consultation process required by Section 7 of the Act.

D. The Effect of a Warming Artic on the Polar Bear

As set forth in our Petition, and in our initial and supplemental comments submitted in response to the Service's positive 90-day finding on the Petition, the

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[39] Holland *et al.* (2006)

principal threat to polar bears is caused by changes to the species' Arctic habitat due to warming temperatures driven by greenhouse gas emissions.

The current global population of polar bears is estimated to be between 20,000 and 25,000, divided into 19 populations, all of which are located in the Arctic. 72 Fed. Reg. at 1069.[40] Polar bears are pagophilic ("ice-loving") mammals and their preferred habitat is the annual sea ice over the continental shelf and inter-island archipelagoes of the Arctic basin. Polar bears are almost completely dependent on sea ice for hunting and migrating, and also rely on sea ice to find mates and, in some populations, to provide dens for pregnant females.

All of these behaviors will be impacted by the anticipated decline in sea ice in the Artic. Of principal concern is the effect of warming and sea ice declines on the availability and abundance of polar bears' main prey, ringed seals (*Phoca hispida*) and bearded seals (*Erignathus barbatus*).[41] These seal species use sea ice as resting places, haul-out sites, feeding grounds and habitats to raise their cubs. Changes in sea ice will likely impact the availability and abundance of seals as prey for polar bears thereby reducing polar bear fat stores, resulting in longer fasting periods and decreasing successful reproductive rates for polar bears.[42]

During the hunting season, polar bears build up stores of adipose tissue and in turn use these stores during periods of low food availability. As discussed earlier, the length of the melt season is increasing by an average of 13.1 days per decade and both winter and summer sea ice extents are near all-time lows. This translates to an earlier spring break-up of sea ice and a later formation of sea ice in the fall. Polar bears tend to come ashore as the sea ice breaks-up in the spring and there is a highly significant relationship between the break-up of sea ice and the conditions of bears when they come ashore due to the amount of fat they have been able to store during the hunting season.[43] Declines in the amount of adipose fat stored are accompanied by declining reproductive rates, declining juvenile survival and declining body mass.

The effects of early sea ice break up can already be seen in the western Hudson Bay. Over the past two decades the condition of adult polar bears in the Bay has deteriorated, with bears showing decreases in body mass. These changes have been reflected in the reproductive cycle of females. For example, between 1987 and 2004 polar bears in the region suffered from a 22 percent decline in population.[44] With a lengthening of the sea ice melt season projected for the future, this decline in body mass is a major concern. Derocher *et al*. (2004) project that with an increase in melt season length of 0.5 days per year, female polar bears in the western Hudson Bay will be under the minimum mass required to rear viable offspring in approximately 100 years**.** Declining body mass and reduced reproductive success rates of female bears in the

[40] Although the polar bear warrants listing throughout its range, for the purposes of recovery planning, Service should designate each of these populations as a recovery unit.
[41] Derocher *et al*. (2004)
[42] Indeed, 2007 has already seen alarming reports of increased mortality among seal pups due to the break up of sea ice, forcing Canadian officials to reduce seal harvest quotas. See Doug Struck, "Warming Thins Herd for Canada's Seal Hunt: Pups Drown in Melting Ice; Government Reduces Quotas," *The Washington Post*, p. A08 (April 4, 2007).
[43] Derocher *et al*. (2004)
[44] Aarls *et al.* (2006)

western Hudson Bay over the past 20 years may be an early sign of the impact of global warming, and it illustrates how the potential impact of a warming Arctic and declining sea ice could be devastating to polar bear populations.

Other signs of nutritional stress are beginning to be recorded. For example, there are indications that adult male polar bears may be turning to cannibalism as a means to supplement their diet. Amstrup (2006) reports three instances of intraspecific predation and cannibalism of polar bears in the Beaufort Sea, including the unprecedented killing of a parturient female in her maternal den. The authors hypothesize that these killings—which are the first reported in 24 years of research on polar bears in the southern Beaufort Sea and 34 years in northwestern Canada—may be caused by nutritional stress due to longer ice-free seasons. A similar incident was recently reported among polar bears on Phippsøya, Svalbard.[45] Other signs of poor nutrition have been recorded in the Southern Beafort sea, where multiple female polar bears and their young have starved to death.[46]

As changes in sea ice extent lead to declines in suitable habitats for polar bears, there may also be an increase in the densities of polar bear populations in some areas. In turn, this will increase the competition for available prey. Increased competition will also result in adult polar bears eating a higher proportion of their kill and therefore leaving less food for younger bears to scavenge. Currently, adult polar bears preferentially feed on the blubber of seals, leaving the protein for younger less-successful hunters.[47] With increased competition and a decrease in hunting success, polar bears will be less likely to leave kill for scavenging bears.

Declines in sea ice extent are also likely to impact the denning behavior of female polar bears. Most female polar bears exhibit a preference for den locations that are on land. As sea ice extent declines, and the sea ice edge moves northwards, polar bears will have to travel greater distances, and expend more energy, to reach their preferred den areas or they will have to change den locations. Although some polar bears build dens on drifting perennial ice (e.g. some populations in northern Alaska),[48] this could also be problematic in the future as sea ice becomes thinner and hence is more prone to drifting. As the distance drifted between den entry by the pregnant female and the re-emergence with cubs increases, female polar bears and their cubs will have to travel longer distances to return to their preferred habitat. This is likely to exacerbate the already lowered fat reserve levels present in most emerging females, and can, in some cases, result in polar bears drowning as they are forced to swim increasing distances to reach the sea ice or land edge. Indeed, recent survey results reported by the Minerals Management Service revealed that in September 2004 at least 4 polar bears, and up to 27, drowned off the north coast of Alaska where the sea ice retreated a record 160 miles from the coast.[49]

As an alternative to traveling long distances, some female polar bears may choose to leave the ice at break-up and summer in the location of their den. Although

[45] Stone and Derocher (2007)
[46] Regehr *et al.* (2006).
[47] Derocher *et al*. (2004)
[48] Derocher *et al*. (2004)
[49] Monnett and Gleason (2006)

this avoids additional energy expended during travel, it will instead require an additional fasting period because females will leave the sea ice feeding grounds earlier than preferred resulting in fasting of up to 8 months.[50]

Some polar bear populations also den in snow, and changes in the proportion of precipitation falling as snow compared to rain will affect such denning behavior. As discussed earlier, it is likely that precipitation in the Arctic will increase in the future, and that the relative quantity of precipitation falling as rain will also increase. This will impact polar bear dens as insufficient snow will prevent den construction or will increase the risk of collapse. The ACIA (2004) reports that den collapses due to increased frequency and intensity of spring rains has already occurred in some cases, resulting in the death of some females and their cubs. In addition to an increase in unseasonable rains, global warming is expected to increase the frequency, extent, and season for forest fires in Arctic regions which, in turn, may significantly reduce availability of suitable denning habitat on land.[51]

Finally, warmer Arctic temperatures associated with increasing greenhouse gas concentrations are also likely to result in an increase in the range of some diseases and parasites that were previously unable to survive the cold climates of the Arctic. If polar bears become food-stressed and weakened due to declining sea ice, their immune systems are likely to decline and hence they will become more vulnerable to these new diseases and parasites.

III. OTHER THREATS TO THE POLAR BEAR POSE A CONTINUING THREAT TO THE SPECIES SURVIVAL IN THE WILD

While the Proposed Rule does a good job in describing the threat the declining sea ice poses to the polar bear, its treatment of factors other than global warming that combine to threaten the polar bear with extinction is disappointing. Continuing and expanded oil and gas exploration, toxic contamination, and over-harvesting in some areas are all additional stressors that threaten the polar bear. Yet throughout the Proposed Rule, the Service states that none of these "as a singular factor" pose a threat to the polar bears continuing existence. See, e.g., 72 Fed. Reg. at 1085. First, and as set forth in greater detail below, for some populations this conclusion simply is not supportable. Considerable evidence exists that, in some areas, continued over-harvest or a catastrophic oil spill could threaten polar bear populations. More broadly, the ESA and its implementing regulations do not require the Service to find that any one factor, in isolation, poses a threat to the continuing existence of a species. Rather, the Act is clear that the Service must determine whether to list a species "because of any one or a combination of" factors. 50 C.F.R. § 424.11(c).[52] The Service must, therefore, determine not just that habitat destruction caused by global warming threatens the polar bear with extinction (which it clearly does) but also whether all of these factors, in combination, also warrant the listing of polar bears as threatened or endangered.

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[50] Derocher *et al*. (2004)
[51] Richardson (2007)
[52] See Carlton v. Babbitt, 900 F. Supp. 526, 530 (D.D.C. 1995) ("FWS must consider each of the listing factors singularly and in combination with other factors."); see also S. Rep. No. 93-307 reprinted in 1973 U.S.C.C.A.N. 2989, 2992 ("The Secretary makes his listing in full consideration of the forces which act to bring about endangerment.").

A. Oil and gas exploration

Oil and gas exploration can have a significant effect on polar bear populations. Oil and gas activities can alter important onshore and offshore polar bear habitat and is often accompanied by air traffic, vessel traffic and other supporting infrastructure. A large oil spill could have catastrophic consequences for polar bear populations.

Anthropogenic noise pollution, generated by seismic exploration and oil and gas development activities, may also have a negative effect on polar bears. Denning polar bears, for example, are likely to be susceptible to disturbance from activities related to oil and gas exploration and development. Noise disturbance from seismic activities of oil exploration as well as ground and air transportation can be heard within 300 meters of dens.[53] A recent study of auditory evoked potentials found that polar bears hear acutely across an unexpectedly wide frequency range and, on this basis, expressed caution over the introduction of noise into their environment.[54] Exposure to noise from drilling and vehicles may cause bears to abandon their dens.[55] In other circumstances, den disturbance has been linked to lower birth weight in female cubs.[56] Given the presence of oil and gas exploration and development in prime polar bear denning habitat, such as along Alaska's north coast, the continuation of such activities may have a detrimental effect on polar bear denning behavior and reproductive success. Noise producing activities may also have a negative effect on the seal species on which polar bears depend.

Finally, as sea ice thickness and extent declines, marine transport routes are expected to open for longer portions of the year. Access to the Northern Sea Route, for example, is projected to increase from the current 20 to 30 days per year to 90 to 100 days per year by 2080.[57] As a consequence the areas available for oil and gas development may also increase.

B. Toxic Contamination

The polar bear, as one of the Arctic's apex predators, is particularly vulnerable to biocontamination from a range of substances, including persistent organic pollutants (or "POPs") and heavy metals. Its vulnerability is exacerbated by certain aspects of its biology, such as its long annual fast, which tends to elevate its toxicity levels at a time when the animal is under greatest stress.

As we observed in our listing petition, the polar bear's risk of exposure to most pollutants has not subsided. The decline in PCB concentrations observed in some parts of the Arctic through the 1990s has begun to level off; some substances that have not been banned, such as PBDEs, appear to be increasing; and global warming stands to create new pathways for concentration of pollutants in the region, with the remobilization of toxics from melting permafrost and the rise of industrial activity as the climate warms. In general, polar bears have been found to carry extraordinarily high loads of some

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[53] Blix and Lentfer (1992)
[54] Nacthingall (2007)
[55] Amstrup (1993); Linnell *et al.* (2000)
[56] Lunn *et al.* (2004)
[57] ACIA (2004)

contaminants in their tissue. Making comparisons to other species that are more available for research is an accepted means of predicting the consequences for polar bear health;[58] but there have also appeared a substantial number of direct studies (summarized in our listing Petition) that correlate changes in hormone production, immune system response, and reproductive success in polar bears with bioconcentrations of POPs.

In our April 8 and June 15, 2006 comment letters, we cited additional research, appearing since the Petition was filed, that provides further evidence of the threat to polar bears from toxic contaminants. Those studies show significant regional concentrations and contaminant loading of chlorinated hydrocarbons (CHCs),[59] perfluorochemicals,[60] organohalogens,[61] radionuclides,[62] and mercury;[63] and give further indication that various chemicals, including PCBs,[64] organochlorines,[65] and organohalogens,[66] are already having serious health impacts on the animals. It is again worth noting that the IUCN, in adding the polar bear to its Red List of Threatened Species last year, included toxic contamination among several additional "population stress factors" (beyond climate change) that could impact polar bear recruitment or survival.[67]

These concerns are only amplified by additional research that has emerged since the supplemental comment period closed last June—particularly on brominated flame retardants like PBDEs, which are rising in the Arctic due to long-range transport from western Europe, eastern North America, and other industrial regions.[68] Studies have demonstrated slow biodegradation[69] and high biomagnification[70] of certain PBDEs in a number of polar bear subpopulations, and a study of the food web in the Norwegian Arctic indicates that some congeners already exceed detection thresholds even in zooplankton and biomagnify specifically through the trophic system.[71] PBDEs and other organohalogens were shown to adversely affect the male and female genitalia of East Greenland polar bears, reducing their size and robustness and potentially compromising reproduction in these animals.[72] The past year also saw further evidence on the health impacts of other contaminants. Organochlorines, for example, were found to alter hormone production in both male and female polar bears; and modeling indicates that

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[58] AMAP (2002)
[59] Verreault *et al.* (2005)
[60] Bossi *et al.* (2005); Braune *et al.* (2005); Kannan *et al.* (2005); Prevedouros *et al.* (2005), Smithwick *et al.* (2005); Smithwick *et al.* (2006)
[61] Kannan *et al.* (2005); Sonne *et al*. (2006a)
[62] AMAP (2004)
[63] AMAP (2005); Braune *et al.* (2005); Dietz *et al.* (2006); Macdonald *et al.* (2005)
[64] AMAP (2005); Lie *et al.* (2004)
[65] Fisk *et al.* (2005)
[66] Sonne *et al.* (2005)
[67] Schliebe *et al.* (2006)
[68] de Wit *et al.* (2006)
[69] Dietz *et al.* (2007)
[70] Muir *et al.* (2006)
[71] Sørmo *et al.* (2006)
[72] Sonne *et al.* (2006b)

even low levels of chronic exposure to these chemicals can impair the reproduction and immune system function of their offspring.[73]

In short, the literature continues to confirm that toxic contamination, independently and in synergy with climate change,[74] threatens the survival of the species.

C. Over-Harvest

Many polar bear populations are currently subject to unsustainable harvest levels either as the result of poaching (as is the case in Russia) or unsustainable hunting practices (as is the case in Greenland and some parts of Canada). Over-harvest of polar bears thus has a concentrated, but potentially severe, effect on several polar bear populations, some of which have already been classified as "declining" by the Polar Bear Specialist Group.[75]

First, poaching of polar bears in the Russian Federation continues to be a serious problem. In 2002, for example, experts estimate that poachers took between 250 and 300 bears on the north coast of Chukotka.[76] Poaching may be exacerbated by receding sea ice, which forces polar bears onto shore early. And more polar bears' skins and other commercial products are being advertised on web sites than ever before.[77] The Proposed Rule rightly points to the Agreement between the United States of America and the Russian Federation on the Conservation and Management of the Alaska-Chukotka Polar Bear Population as a regulatory mechanism that may alleviate illegal harvest of polar bears in Russia. While commendable, however, this Agreement cannot influence the Service's evaluation of the threat illegal hunting poses to Russia's polar bear populations, as its provisions are yet to be implemented or proven effective.[78]

Second, the level of legal harvest of some polar bear populations in Canada and Greenland are far too high and, in and of themselves, may threaten the continued existence of these populations. For example, despite the scientific evidence, discussed above, that the western Hudson Bay population is experiencing severe declines, the Proposed Rule notes that, while this population has a maximum sustained yield of only 44 bears, Canada allows 62 bears to be removed from the western Hudson Bay. 72 Fed. Reg. at 1084. The result is that the Western Hudson Bay population has a 99.9 percent probability of decline during 1, 3, and 5 year mean kill averages. The Proposed Rule also reports that quotas set for the Kane Basin, Baffin Bay, and Davis Straight populations are also predicted to result in near-certain declines. Id. To make matters worse, some governments have actually increased harvest levels in recent years. For example Nunavut increased quotas for 8 polar bear populations, leading to harvest practices that the Proposed Rule rightly identifies as "questionable." Id. at 1084. As with poaching, receding sea ice likely brings more polar bears in contact with people, increasing hunting opportunities and potentially leading to misperceptions of polar bear

[73] Ropstad *et al.* (2007)
[74] See, e.g., Jennsen (2006)
[75] Aars *et al.* (2006)
[76] Ovsiyanikov (2003)
[77] *Ibid*
[78] Defenders of Wildlife v. Norton, 258 F.3d 1136, 1146 (9th Cir. 2001)

abundance.[79] These harvest levels are particularly troubling, given that the Polar Bear Specialist Group considers a 20 percent risk of decline for a population over a 10-year period to be "unacceptable." Aarls *et al.* (2005).

In short, there is ample evidence that, in combination, polar bears are threatened with extinction not just by global warming but by oil and gas exploration and development, toxic contamination, and over harvest. Indeed, as discussed, global warming acts synergistically, serving to increase the risks posed by all these factors. Greater access to previously remote areas will bring more human interactions with polar bears, possibly including increased hunting, accidents, dumping and migration of toxic chemicals, spills of hazardous substances, and the disruptions from anthropogenic noise. Cumulative impacts from all of these stressors are likely to increase, as human presence in the Arctic grows.

IV. THE SERVICE SHOULD DESIGNATE POLAR BEAR CRITICAL HABITAT

The ESA requires the Service to designate critical habitat "to the maximum extent prudent and determinable" at the same time that it lists a species as endangered and threatened.[80] Here, the Proposed Rule states that designating critical habitat for the polar bear is not "determinable" because identifying such habitat is "complicated" and will require "additional time and evaluation." 72 Fed. Reg. at 1096. A not determinable finding, however, may only be made if the Service does not have enough information "to perform required analyses of the impacts of the designation," or cannot sufficiently asses "biological needs of the species . . . to permit identification of an area as critical habitat." 50 C.F.R. § 424.12(a)(2). Here, neither conclusion is supported by record, the best available science, or even by the Proposed Rule itself.

As the Proposed Rule explains, habit features essential to the conservation of the polar bear (that is, those features that meet the ESA's definition of critical habitat), are well-understood and

> include annual and perennial marine sea ice habitats that serve as a platform for hunting, feeding, traveling, resting, and to a limited extent, for denning, and terrestrial habitats used by polar bears for denning and reproduction for the recruitment of new animals into the population, as well as for seasonal use in traveling or resting.

72 Fed. Reg. at 1096. What's more, the Proposed Rule provides considerable detail about each of these features.

For example, with regard to sea ice habitat, the Proposed Rule explains that Stirling (1993) identifies seven types of sea ice: "The seven types of sea ice were: stable fast ice with drifts; stable fast ice without drifts; floe edge ice; moving ice; continuous stable pressure ridges; coastal low level pressure ridges; and fiords and bays." 72 Fed. Reg. at 1072. What's more, the Proposed Rule notes that polar bears concentrate "on the floe ice edge, on stable fast ice with drifts, and on areas of moving ice." Id. (citing Stirling 1990).

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[79] Stirling and Parkinson (2006)
[80] 16 U.S.C. § 1533(a)(3); 50 C.F.R. § 424.12(a).

Similarly, with regard to denning habitat, the Proposed Rule provides considerable detail about the type of habitat preferred by polar bears and the distribution of polar bear dens. In fact, the Proposed Rule includes a map of polar bear terrestrial denning areas, 72 Fed. Reg. at 1078 (*Figure 2*).[81]

Given the level of detailed information on the polar bears' habitat needs and the detailed description in both the Proposed Rule and the Status Review of polar bear habitat distribution and the location of core denning areas, the Service's finding that critical habitat is not "determinable" is not supported by the record. The Service should promptly propose a critical habitat designation for the polar bear.

V. CONCLUSION

The polar bear is a highly imperiled species facing multiple threats to its survival, most importantly global warming. Since our Petition to list the polar bear as a threatened species was filed, the scientific evidence confirming these threats has only grown. The severity and wide-ranging effects of global warming on Arctic ecosystems is better established and more certain; additional research on toxic contamination in polar bears have confirmed its prevalence; oil and gas activities are expanding; and over harvest of polar bears in some areas continues unabated. The IUCN's "Red List" now classifies polar bears as "vulnerable," defined as "a species facing a 'high risk of extinction in the wild.'"[82] Of the world's 18 polar bear populations, the Polar Bear Specialist Group classifies five of them as "declining" and six as having insufficient data to allow reliable classification. Only two polar bar populations are thought to be increasing.[83] As a result there simply is no question that the polar bear should be listed under the ESA.

Sincerely,

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[81] Both the Status Review and the Proposed Rule also include citations to Durner, et al. (2002), which also contains a map of polar bear den sites in the Beaufort sea.
[82] Schliebe *et al.* (2006)
[83] Aars *et al.* (2006). The fact that so many populations are poorly surveyed is significant. As a recent paper analyzing the difficulty in accurately surveying polar bears pointed out, on average researchers have less than a 50 percent chance of detecting a catastrophic decline (i.e., a 50 percent drop in polar bear abundance over 15 years) of polar bear populations. Taylor *et al.* (2007)

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