United States Fish and Wildlife Service responses to comments on USGS reports prepared in support of the Polar Bear Listing Decision February 25, 2008

Introduction

On January 9, 2007, we published a proposed rule in the Federal Register to list the polar bear as a threatened species under the Endangered Species Act (72 FR 1064). The Secretary of the Interior asked the U.S. Geological Survey (USGS) to assist the U.S. Fish and Wildlife Service (Service) by collecting and analyzing scientific data and developing models and interpretations that would serve to enhance Service understanding of the status of the polar bear for the listing decision.

The USGS provided the Service with their scientific analysis in the form of nine reports. These reports analyze and integrate a series of studies on polar bear population dynamics, range-wide habitat use, and changing sea ice conditions in the Arctic. These reports are:

(1) Polar Bear Population Status in the Northern Beaufort Sea by Stirling et al.

(2) Polar Bear Population Status in Southern Hudson Bay Canada by Obbard et al.

(3) Polar Bears in the Southern Beaufort Sea I: Survival and Breeding in Relation to Sea Ice Conditions, 2001-2006 by Regehr et al.

(4) Polar Bears in the Southern Beaufort Sea II: Demography and Population Growth in Relation to Sea Ice Conditions by Hunter et al.

(5) Polar Bears in the Southern Beaufort Sea III: Stature, Mass, and Cub Recruitment in Relationship to Time and Sea Ice Extent Between 1982 and 2006 by Rode et al.

(6) Uncertainty in Climate Model Predictions of Arctic Sea Ice Decline: An Evaluation Relevant to Polar Bears by DeWeaver.

(7) Predicting the Future Distribution of Polar Bear Habitat in the Polar Basin from Resource Selection Functions Applied to 21st Century General Circulation Model Projections of Sea Ice by Durner et al.

(8) Predicting Movements of Female Polar Bears between Summer Sea Ice Foraging Habitats and Terrestrial Denning Habitats of Alaska in the 21st Century: Proposed Methodology and Pilot Assessment by Bergen et al.

(9) Forecasting the Range-wide Status of Polar Bears at Selected Times in the 21st Century by Amstrup et al.

To ensure the analysis met scientific rigor and was consistent with the elements set out in the Office of Management and Budget's December 16, 2004, "Final Information Quality Bulletin for Peer Review", as well as USGS's own guidelines, the reports were first peer reviewed by a minimum of two independent reviewers who were selected based on their scientific expertise and experience. Further, they were chosen based on their complete independence from the development of the nine reports, as well as an absence of a conflict of interest associated with the reports. These reports were then revised by the USGS based upon peer review comments and provided to the Service in September of 2007. The Service, in turn, reopened the public comment period on September 20, 2007 (72 FR 53749) for 15 days [extended until October 22, 2007 (72 FR 56979)] notifying the public of the availability of the reports and the intent to consider them in making the final listing determination. Public comment on these reports was also requested.

During this public comment period, the Service received approximately 80,000 comments from Foreign Governments, State Agencies, commercial and trade organizations, conservation organizations, non governmental organizations, and private citizens. The following summary responds to those comments as they apply across all nine reports and as they apply to individual USGS reports:

Summary of General Comments Regarding the USGS Reports

Comment (1): The link between the loss of sea ice and declines in polar bear populations is not adequately made within the USGS reports.

Response: Regehr et al. (2007a) demonstrated a statistically significant link between loss of sea ice habitat and polar bear declines within the Western Hudson Bay population. Similarly, Regehr et al. (2007b) demonstrated a link between loss of sea ice habitat and survival for the Southern Beaufort Sea population. On the basis of ongoing studies, there are strong indications that future stresses upon polar bear populations will develop and magnify as a consequence of continued loss of sea ice. The Service recognizes that there are only a few longterm data sets on polar bear populations from which inferences can be derived. For the majority of polar bear populations, longterm population data do not exist to determine whether numbers are declining as a consequence of loss of sea ice, or are unchanged. In its reports, the USGS divided the polar bear range into four ecoregions, based on how sea ice forms, moves, and melts during the annual cycle. What we understand about how specific polar bear populations, for example in the Southern Beaufort Sea, Northern Beaufort Sea and Western Hudson Bay, are responding to changes in sea ice in some of these ecoregions, gives us a point of reference from which to predict how other populations within the same ecoregions will likely respond to similar changes in sea ice. Therefore, a lack of data on other polar bear populations cannot be construed as evidence that loss of sea ice is not affecting those populations.

Comment (2): The climate scenarios should include implementation of the United Nations Framework Convention on Climate Change (UNFCCC) and/or the emission targets of the Kyoto Protocol.

Response: The current-generation General Circulation Model (GCM) simulations utilize the emissions scenarios developed by the Intergovernmental Panel on Climate Change (IPCC) in the Special Report on Emissions Scenarios (SRES). The SRES scenarios do not include specific mitigation initiatives, which means that no scenarios are included that explicitly assume the implementation of the UNFCC or the emission targets of the Kyoto Protocol. The USGS reports examined only the SRES A1B emission scenario, often coined the "middle of the road" or "business as usual" scenario. The A1B scenario was chosen because it most accurately reflects what is occurring today and what can conservatively be projected for the future. Thus the reports are based on the best currently available information and not on scenarios that speculate on the future implementation of measures to mitigate greenhouse gas (GHG) emissions.

Comment (3): The definition of habitat in terms of the percent of sea ice cover differs between the USGS reports, with some USGS reports incorrectly identifying a less then 50 percent cover as being ice-free, and by implication, a lack of use by polar bears.

Response: The definition of habitat in terms of the percent of sea ice cover used by polar bears did not differ between the reports. Durner et al. (2007) evaluated polar bear selection of sea ice habitat of all ice concentrations. His results, as well as those of others (Stirling et al. 1999; Durner et al. 2006), suggest that optimal polar bear habitat consists of sea ice concentrations greater than 50 percent. Therefore, the other reports (e.g., Regehr et al. 2007; Rode et al. 2007) used 50 percent as a critical threshold to identify the availability of optimal polar bear habitat in relation to population demographics. While polar bears will utilize areas where ice cover is below 50 percent, it is not preferred habitat. For example, in the Western Hudson Bay, data demonstrate that approximately 2-3 weeks after ice cover reaches 50 percent or less, the bears go ashore, even though there may continue to be some ice present (Stirling et al. 1999). This suggests that 50 percent ice cover is a threshold where at lower percentages of ice-cover, at least in the Western Hudson Bay, it is no longer energetically effective for bears to continue to remain on the ice. The habitat analysis by Durner et al. (2007) examined a broad range of sea ice concentrations (15-100 percent) and their results corroborated the Western Hudson Bay observations, as did other polar bear habitat studies (Durner et al. 2004; Durner et al. 2006; Mauritzen et al. 2003; Arthur et al. 1996).

Comment (4): New information on sea ice projections in marginal seas as well as the 2007 sea ice retreat data should be incorporated into the analysis.

Response: The USGS analysis was conducted prior to release of the Overland and Wang (2007) analysis of sea ice projections in marginal seas, and prior to the occurrence of the 2007 sea ice minimum. Nevertheless, the final rule does consider this new information and detailed discussions may be found in the "Projected Changes in Arctic Sea Ice" and the "Observed Changes in Arctic Sea" sections, respectively, of the climate change discussion under Factor A.

Comment (5): Satellite data do not accurately depict sea ice use by polar bears.

Response: Satellite data are well established and broadly accepted as the principal tool for following the movements, distribution, and habitat use of polar bears. We believe the data are accurate for adult female polar bears. Adult female polar bears are the most important cohort with respect to population dynamics. Although there is very little information on the movements of adult male polar bears, results from a preliminary study involving satellite tracking by Amstrup et al. (2001) suggest that movements of male and female polar bears were comparable between April and September. Similarly, an inter-seasonal analysis of the movements of tagged and recaptured or harvested male and female polar bears, or between the same seasons in different years, in the Canadian High Arctic found no significant differences (Stirling et al. 1984). While these studies may not be definitive, they do suggest that movement patterns of male and female polar bears within the same populations are similar.

Comment (6): The lack of good polar bear abundance estimates calls into question the credibility of the empirical relationship between carrying capacity and abundance with shrinking sea ice habitat.

Response: Information on the abundance of polar bears, their interdependence on sea ice availability, and the reduction of sea ice habitat, are all well studied and documented. Where used in the USGS reports, the term carrying capacity was explicitly defined and projected forward only in the context of that definition. The varying quality of population estimates was acknowledged and all projections of future carrying capacities were expressed in a "compared to now" frame-work, thus the analyses are less sensitive to possible variances in the accuracy of the original abundance estimates.

Comment (7): Inuit have observed considerable fluctuations in polar bear populations and densities over the past century.

Response: We appreciate the input of Traditional Ecological Knowledge (TEK) and, to the extent that such knowledge and observations are available, we have incorporated information from this source into the final rule. The USGS report authors also incorporated traditional insights into their studies to the extent that such information was obtained through personal interactions and informal discussions during their careers working in the Arctic and interacting with local residents. While TEK was considered in the analysis, the qualitative nature of TEK makes it difficult to incorporate within the current framework, which integrates climate and population models. We recognize that TEK provides valuable information regarding local variability in polar bear distribution and indications of possible causes of that variability; however, we also acknowledge that TEK may be limited in providing a quantitative way of determining if fluctuations in observations relate to population size and trend.

Comment (8): The models are too complex to determine potential trends and the underlying assumptions are not clear.

Response: Models provide useful tools for understanding complex environmental relationships and developing future forecasts and projections. In all cases, the underlying assumptions and associated uncertainties for each model are explicitly described in the reports. Model complexity often relates to the number of variables incorporated within the model. For example, models developed to present a synthetic overview, such as the Bayesian Network model (BM), are complex by design. The USGS reports incorporated a number of different modeling approaches. The fact that results from all of these models pointed in the same direction, despite varying inputs and assumptions, adds strength to the findings. The reports contain tables and explanatory information that clearly describe all factors and assumptions considered in the models. We also note that the use of multiple models helps to avoid excessive dependence on any single set of assumptions.

Comment (9): The reports failed to consider previous warming periods and the ability of polar bears to adapt and survive during these times.

Response: Polar bear evolution through previous warming periods was not explicitly considered in the modeling studies undertaken by USGS because the time scales of the current analyses were short—a century—compared to time scale of the past warming periods (i.e., millennia). In its final rule, the Service provided a discussion of polar bear adaptability to climate change, as well as a discussion of polar bear existence through previous warming periods (see discussion under Factor A in the final rule to list the polar bear as a threatened species).

Comment (10): The models should include a scenario in which the greenhouse gases are capped at a much lower level.

Response: Current-generation GCM simulations utilize the emissions scenarios developed by the IPCC in the Special Report on Emission Scenarios (SRES). The SRES scenarios are considered to be plausible future emissions scenarios based on assumptions on how societies, economies, and energy technologies are likely to evolve. The SRES emissions scenarios were built around four narrative storylines that describe the possible evolution of the world in the 21st century (ACIA 2005, p.119), but the SRES scenarios do not include specific mitigation initiatives. Around these four narrative storylines the SRES constructed six scenario groups and 40 different emissions scenarios. Six scenarios (A1B, A1T, A1FI, A2, B1, and B2) were then chosen as illustrative "marker" scenarios. These scenarios have been used to estimate a range of future greenhouse gas (GHG) emissions that affect the climate. Developing an alternative emissions scenario that caps GHGs at much lower levels assumes implementation of an as yet unknown management strategy or new technology, and, as such, is speculative. Such speculation was beyond the scope of the USGS modeling effort.

Comment (11): It is questionable whether ice will continue to decline.

Response: The USGS relied on the numerous and most up-to-date peer-reviewed references concerning Arctic sea ice as well as the most recent IPCC AR4 reports in their assessment of future sea ice habitat for polar bears. Similarly, the Service relied on the numerous and most up-to-date peer-reviewed references concerning sea ice as well as the most recent IPCC AR4 reports. Although climate models (GCMs) vary in the rate and magnitude of sea ice loss they project into future decades, all GCMs project a continuing decline in Arctic sea ice. In the final rule, the Service determined that the observational record as well as the model projections published in the current scientific literature on sea ice and climate represent the best available scientific information and provide compelling evidence and unequivocal support for the conclusion that climate warming and sea ice declines will continue.

Comment (12): More research and a comprehensive approach is required to address the uncertainties associated with the ability of climate models to accurately reflect natural climate—sea ice—polar bear relationships and polar bear responses (adaptation) to climate change.

Response: While additional research on these topics is certainly desirable, we believe that a tremendous body of sound scientific data is available, and that information formed the basis for the USGS reports as well as the Service's decision in the final rule. Furthermore, we note the caveat expressed by many climate modelers and summarized by DeWeaver (2007), "even if climate models perfectly represent all climate system physics and dynamics, inherent climate variability would still limit the ability to accurately issue detailed forecasts (predictions) of climate changes, particularly at regional and local geographical scales and time scales greater than a decade." Thus, it is simply not possible to engineer all uncertainty out of climate models, and climate scientists expend considerable energy in trying to understand and interpret that uncertainty. The section in the preamble of the final rule entitled "Uncertainty in Climate

Models" discusses uncertainty in climate models in greater depth than can be presented here.

Summary of Comments on Specific USGS Reports

Polar Bear Population Status in the Northern Beaufort Sea (Stirling et al. 2007)

Comment (13): The authors make selective use of information and state that estimates of abundance were markedly similar through the 1970s, 1980s, and 2000s, although the population appeared to increase if point estimates were used. The authors should report the population from 2004-2006 as 980-1200 rather than 980.

Response: The authors accurately report on abundance estimates developed for three periods of time when capture programs were active. The current population point estimate of 980 is a modeled average of the 2004-2006 population data. Model averaged estimates are known to provide the most statistically robust estimate when the model set is complete and the underlying data are unbiased. The status designation of "stable" is justified, discussed in detail, and based on the results demonstrating that the abundance point estimates occur within the confidence limits of each estimate. The authors describe single year point estimates for the 2004-2006 study and provide insights as to the differences in abundance estimates derived for each single year. They also acknowledge that the model averaged abundance estimate may be conservative.

Comment (14): This report does not consider the increased availability of walrus as a potential food source.

Response: Walrus do not generally occur within the Northern Beaufort Sea and thus are not considered an alternate prey source there.

Comment (15): The qualitatively different status of the Northern Beaufort Sea and the Southern Beaufort Sea populations demonstrates the fallacy of the range-wide determination.

Response: The Northern and Southern Beaufort Seas differ in their current sea ice conditions and projected changes in those conditions, and these will influence the status of their respective polar bear populations. The Southern Beaufort Sea is subject to significant seasonal ice losses, while the Northern Beaufort Sea is subject to sea ice accumulation. The USGS reports appropriately describe the different consequences to polar bears that are occurring simultaneously in these two regions. The comparative nature of these studies indicates the significance of relatively stable versus declining amounts of sea ice at critical times for polar bears. Despite these regional differences, sea ice is forecast to decline in all regions. Threats from declining sea ice will vary in timing and magnitude by population over time, but, overall, the loss of sea ice will ultimately have a negative impact on populations across the range of this species within the foreseeable future.

Comment (16): The decadal oscillation covariate seems to greatly complicate the ice and climate models.

Response: A decadal oscillation covariate was not included in the analysis. Other mechanisms such as the unidirectional loss of sea ice are the principal factor affecting polar bears. The authors incorporate two sea-ice covariates within the analysis. Neither covariate specifically includes decadal oscillation, but *de facto*, may incorporate any influence that the decadal oscillation may have had on sea ice present within the study area during the study period. The seal availability covariate may also partially address decadal oscillations shown to affect seal productivity during a year of extreme heavy ice, with a resultant 3-year influence on polar bear productivity. This study, however, did not establish a significant relationship for the sea ice or seal covariates with polar bear population trends.

Comment (17): The apparent contradiction between the primary problem of less ice and problems with heavy ice need to be clarified.

Response: The effects of reduced sea ice on polar bears are now documented for Western Hudson Bay and the Southern Beaufort Sea, and the USGS reports project how the rangewide status of polar bears will likely change in response to further reductions in sea ice through the 21st century. But there is also evidence that particularly heavy ice can negatively affect polar bears thru reduced productivity and availability of ice seals. Stirling et al. (2002) and Stirling et al. (2007) found that reduced survival and natality of polar bears in the Northern Beaufort Sea coincided with reduced seal productivity that was associated with very heavy ice.

Comment (18): It is unclear whether polar bears sampled from 1992-1994 were included in estimating the survival and what impact selective sampling had on model projections.

Response: In 1992-1994, sampling of polar bears was focused in the northern part of the study area around Prince Patrick Island in order to determine if a substantial number of bears existed there. The bears sampled from 1992-1994 were included in the survival estimates and are presented in the report. The survival estimates are accurate because mark-recapture methods are known to be unaffected by temporary unavailability of some bears to capture (i.e., survival estimates are robust to temporary emigration) (Manly et al. 1999). It is not clear from the comment what is meant by selective sampling, but estimates of survival were not used for population projections. The mark-recapture data were used to estimate population size.

Comment (19): Information and statements regarding emigration and mixing of Northern Beaufort Sea and Southern Beaufort Sea bears is appropriate for future application of Distinct Population Segments.

Response: The authors considered emigration rates and whether they influenced survival rates. Emigration was determined not to affect survival rates in this analysis because the accuracy of the survival estimates is insensitive to temporary emigration (Manly et al. 1999). The objectives of this study did not include delineating population boundaries, but previous telemetry studies have provided scientific support for delineating boundaries of these populations.

Polar Bear Population Status in the Southern Hudson Bay, Canada (Obbard et al. 2007)

Comment (20): The present demographics for this population do not warrant listing since there is no statistical evidence of a decline (alpha>0.05).

Response: We agree that there is not enough evidence in the data to conclude that a decline has been occurring; however, this does not rule out the possibility that the population could be in decline. Body condition indices for all sex and age classes of polar bears have declined significantly over the last 20 years in Southern Hudson Bay and thus, as the authors indicate, it is reasonable to expect that a continued decline in condition resulting from continued reductions in the amount and timing of sea ice would ultimately affect recruitment, survival, and population trend. The parallels to the decline in the polar bear population in Western Hudson Bay are clear. See also response to Comment 26.

Comment (21): The Western Hudson Bay population decline is not as great as previously thought since the study overlooked polar bears that overwinter north of the Seal River.

Response: Mark and recapture studies were conducted during early 2007 in the area north of Seal River to explore the possibility that the polar bear population was being under-reported. Capture results revealed that only a small number of bears inhabit this area and that a similar proportion of these bears had been sampled or captured previously in the Western Hudson Bay studies. Although there were a few bears north of the Seal River, which has long been known, the ratio of marked to unmarked bears clearly show they were accounted for in the population estimates for the Western Hudson Bay population.

Comment (22): Why are there no data reflected for the time period 1987 through 1998? Are data missing or not used?

Response: Data are missing. Mark and recapture programs were not conducted during this time frame, as noted in the report.

Comment (23): Statistics should be applied consistently.

Response: We believe this comment pertains to reporting of non-statistically significant trends in population size. The authors are clear in their reporting on the results of abundance estimates. Regarding the application of non-statistical trends to future conditions, the authors present logical rationale for their statements which are presented as testable hypotheses. The rationale of the authors is also supported by previous case studies documenting statistically significant changes for population trend over time observed in the adjacent Western Hudson Bay population.

Comment (24): Conclusions and projections about the status of the Southern Hudson Bay population, particularly as it pertains to referencing the Western Hudson Bay population, should be toned down.

Response: The authors have appropriately justified their conclusions and projections within the discussion section. We find that they are accurately presented, qualified, and supportable.

Comment (25): Population numbers may be biased low because the Twin and Akimiski Islands in James Bay (Government of Nunavut jurisdiction) were not included in the analysis.

Response: The authors indicate in the discussion section of the report that polar bears occupying islands or coastal sections of James Bay were not included. Polar bears on the mainland north of Hook Point were captured during both intensive capture periods and were included in the analysis. There is substantial anecdotal and some quantitative evidence that bears residing on James Bay islands are a relatively separate and constant portion of the overall Southern Hudson Bay population. Bears were captured on Akimiski Island and on North and South Twin Islands in 1997 and 1998, a period outside of either intensive sampling period (M. E. Obbard and M. K. Taylor, unpublished data). Crompton (2005) analyzed the genetic structure of bears from the Hudson Bay system and concluded that there was evidence of a distinctive James Bay cluster within the Southern Hudson Bay population. This information suggests that 70-110 animals should be added to the abundance estimate to provide an estimate of the total size of the Southern Hudson Bay population. The reported analysis, that did not include Akimiski or North and South Twin Islands, is appropriate for estimation of trends in abundance because these islands were not consistently surveyed. Inclusion or non-inclusion of a correction factor for polar bears in James Bay would not affect overall conclusions of the study.

Comment (26): There is weak evidence that survival and population size is declining and thus no evidence exists since the null hypothesis was not disproven. It is, therefore, inappropriate to speculate on future trends in comparison to Western Hudson Bay.

Response: There is evidence from Western Hudson Bay that changes in body condition and survival preceded a population decline. In the case of polar bears in Southern Hudson Bay, Obbard et al. (2007) documented declines in survival estimates for male and female polar bears, but the imprecision of the estimates precluded a conclusion that the declines were not due to chance alone. However the declines in body condition for polar bears in this population, previously documented by Obbard et al. (2006), suggested to the authors that the Southern Hudson Bay population may be on a similar trajectory to the adjacent Western Hudson Bay population, where declines in body condition preceded subsequent declines in survival and population size. The authors also suggest that differences in sea ice melt patterns between Western and Southern Hudson Bay may explain the apparent lack of synchrony between these two polar bear populations. We believe the uncertainty associated with these conclusions was appropriately characterized in the discussion section of the paper. The authors appropriately considered the significant changes in condition of bears and breakup dates of the sea ice in evaluating the future status of this population.

Comment (27): A recent paper by Dyck et al. (2007) casts doubt on the causes for population declines in Western Hudson Bay and offers alternative hypothesis.

Response: The rebuttal of Dyck et al. (2007) by Derocher et al. (in press) addresses and refutes the primary contentions of the Dyck et al. paper. Specifically Derocher et al. (in press) provide evidence that changes in air temperature and sea ice have corresponded with changes to polar bear condition, survival, and population size in Western Hudson Bay. Additionally, Stirling et al. (in review) indicate that there is evidence to contradict the contention that human-caused effects from research and live capture programs or tourism have been responsible for changes in demographic parameters of polar bears in this area. Mechanisms of adaptation suggested by Dyck et al. (2007) are evaluated and discounted based on well understood physiological and nutritional constraints for polar bears.

Polar Bears in the Southern Beaufort Sea I: Survival and Breeding in Relation to Sea Ice Conditions, 2001-2006 (Regehr et al. 2007)

Comment (28): The models involve a great level of uncertainty and should not be used.

Response: We recognize that there is always uncertainty associated with any study. The challenge is in understanding how uncertainty factors into the analyses and what influence it has on the results. We find that sources of variance have been identified and, to the extent possible, they are included in the analysis. The authors clearly describe the variance and assumptions that went into the analysis, and conclusions that resulted were based on sound empirical data. The conclusions are drawn with an understanding of the full extent of uncertainty within the results and they represent the best available science.

Comment (29): The impact of the number of ice free days on the Southern Beaufort Sea is exaggerated. It appears that there may be a threshold such as 127 ice free days that results in reduced survival.

Response: The report accurately documents and accounts for sources of variability in the analysis. The results based on empirical data clearly show that the number of ice free days over the continental shelf affected survival rates in the Southern Beaufort Sea from 2001-2006, and that a threshold in this relationship exists around 127 days. During that period adult female, breeding, and cub-of-the-year survival declined during the years (2004-2005) that had longer ice free periods (mean = 135 days). Regehr et al. (2007) did not extrapolate changes in survival rates for periods with greater durations of the ice-free state. Although the increasing trend in the number of ice-free days was not statistically significant from 1979-2006, a consistent trend for Arctic-wide diminished sea ice exists. Additionally, Hunter et al. (2007) did not extrapolate beyond the estimated survival rates. Projections with greater than 127 ice-free days in a given year used the average estimated survival rates from 2004-2005 for that year.

Comment (30): It is not clear why the study was limited to 2001-2006 since there is satellite data available from 1979. It is very difficult to quantify demographic trends based on 5 yearly intervals from 2001 to 2006.

Response: The authors used data collected from 2001-2006 because they collected the most consistent and complete data on polar bear population dynamics in the Southern Beaufort Sea during this period. Previous research efforts varied in objectives and sampling effort and therefore were not included. Ice data from 1979 to 2006 were included in the analysis. This report notes the limitations of quantifying demographic trends based on a 5-year interval and notes that, as with all research, longer term studies with larger data sets are preferred. We find, however, that there is no reason to believe that, given the predicted climatic changes in the Arctic (i.e. increased warming), a longer term data set would refute the relationship between the declining sea ice and decreased survival.

Comment (31): It is not clear how survival rates were estimated.

Response: Calculations of survival rates were based on well established statistical methods and are described in detail on pages 5-10 of the report.

Comment (32): The age of first reproduction for females noted as 5 years was disputed since some females breed at 4 years of age. Also males may breed as early as 3 years of age.

Response: In the Southern Beaufort Sea population, while female polar bears can breed as sub-adults at age 4 and others may delay breeding to 6 or 7, more than 20 years of population data confirm that 5 is the most common age of first reproduction. Although females often breed for the first time at 4 years of age in other populations, this is very uncommon in the Southern Beaufort Sea and there were no instances of females breeding at 4 years of age in the 2001-2006 study. Age of first reproduction for males is not considered an important factor regarding population dynamics and modeling, and thus, no assumptions were made regarding the first age of reproduction for males.

Comment (33): The temporary emigration of 0.2 has relevance to the issue of distinct population segments (i.e., non-independence of study areas or populations) and should be addressed.

Response: Temporary emigration in the context of this study referred to the bears that were outside the range of the search area of the helicopters and was used to determine if it introduced any bias to the parameter estimates. It does not mean that polar bears left the area occupied by the Southern Beaufort Sea population. The results indicated that temporary emigration as defined in this study did not introduce any bias to the survival estimates.

Comment (34): The analysis relies only on a subset of the population, the adult females collared within 100 km of the coast.

Response: The capture work is logistically limited to approximately 100 km from the coast. However, collectively, the length of the study, the extent of the study area, and the random nature of encounter and capture is designed to ensure that all the bears (each sex/age class) have an equal (non-zero) probability of being captured although there is some level of heterogeneity in capture probability. The study was not restricted to adult females. For the mark—recapture effort both males and females were caught and tagged. Furthermore, over the 2001-2006 capture period, a high percentage of bears that had been previously marked were recaptured in 2005 and 2006. This high recapture rate illustrates strength of the sampling effort for the complete data set.

Comment (35): The large confidence intervals for adult female survival should be explained.

Response: The large confidence intervals are based in part on the limited size of this subset of data and the low capture probability for adult female polar bears. Implications of the wide confidence intervals are explained in the report.

Comment (36): Specific comments that were noted by page and line numbers should be reviewed by authors.

Response: We acknowledge that additional specific comments were made on the report. In coordination with the primary authors of the reports, we have included, identified, and responded to specific concerns within this document.

Comment (37): The assumptions that led to the extrapolation of survival rates are invalid.

Response: This comment was based on the premise that survival rates of subadult males, adult males, and subadult females should have been included in the analysis. These sex/age classes (stages) were included in the analysis under the section Survival Constraint Analysis. No extrapolations of the survival rates were made beyond what estimates were used in the demographic modeling.

Comment (38): Significant numbers of bootstrap replicates as outliers (impossible probabilities) is an indication of bias in the estimated probability. Simply culling these inconvenient results gives an overly optimistic outlook on the accuracy of the estimated probability. The authors should report the estimated bias from the complete set of bootstrap replicates for each statistic.

Our response: All the bootstrap replicates, which are evidence of variability not bias, were reported. There was no culling of data. Many of the figures show a complete set of bootstrap runs and others are summarized in the box-plots. High variability in the re-sampled (bootstrap) replicates is not an indication of bias.

Comment (39): No trend of increase in the number of ice free days in the Southern Beaufort Sea region is evident in Figure 3 of the report. This is also evidence in the report prepared by Rode et al (2007) that shows a non-significant trend in percent days with 50 percent ice.

Response: The report did not assume that there was a trend in the number of ice free days between 2001 and 2006. The data were used to evaluate the inter-annual variability and to evaluate the relationship of sea ice with survival rates (there were no projections in this report). The Resource Selection Functions (RSFs) from Durner et al. (2007), which were not available to Rode et al. (2007) as both reports were being prepared concurrently, presents a more accurate sea ice metric. Even though different ice metrics were used for this report, the sea ice covariate (number of ice free days over the continental shelf at depths < 300 meters (m)), was highly correlated with the RSF habitat index developed by Durner et al. (2007) for the years of the study (2001-2006). Durner et al. (2007) used empirical data to establish the relationship between sea ice and polar bear habitat use and then used the General Circulation Model (GCM) projections to predict future habitat distributions.

Comment (40): The uncertainty of point estimates of survival rate was not addressed in projections of survival rates.

Response: The premise of this question is incorrect. Uncertainty was fully evaluated and analyzed within all of the projections. In particular, to appropriately characterize uncertainty associated with polar bear demography and population status in the southern Beaufort Sea, USGS derived estimates of sampling and environmental variation associated with estimates of vital rates and fully incorporated that variation into their population projections. That is, the full range of outcomes possible from the confidence limits on estimates of parameters such as survival rate or breeding rate was incorporated into projections. In addition to these stochastic estimates, demographic projections also were made with mean values, and both sets of results compared and contrasted. As with selection of climate models, the USGS did not just pick a particular set of point estimates but rather explored the full range of variation in all estimates.

Comment (41): Logistic functions (i.e., Figure 6 in the report) are extrapolations not fitted curves; these are based on speculation not observations.

Response: The functions are fitted curves based on the patterns in the observational data. It is important to be aware that the population projection modeling only used the values for the functional relationship between sea ice cover and polar bear survival within the range of observations. A longer time series of data on sea ice and polar bear survival will be needed to understand what happens to survival when the number of ice free days is much greater than those observed during this study.

Polar Bears in the Southern Beaufort Sea II: Demographic and Population Growth in Relation to Sea Ice Conditions (Hunter et al. 2007)

Comment (42): This report treats areas with ice-coverage less than 50 percent as if they were ice-free, and excludes them from the analysis when they have non-zero sea ice values and are used by polar bears.

Response: The ice metric was based on days with less than 50 percent ice cover in areas greater than 300 m depth and was used as an index. It did not exclude any areas from the analysis and made no assumption about the use of these areas by bears. "Ice free days" was simply the term used to describe this metric. Both Regehr et al. (2007) and Hunter et al. (2007) make no assumptions about use of areas under conditions with less than or greater than 50 percent ice. They describe survival in relation to the number of "ice free days" in a given year. The authors selected this ice metric based on a relationship that had been established previously in Western Hudson Bay and the Southern Beaufort Sea. In Western Hudson Bay, polar bears were found to leave sea ice within 2 to 3 weeks after it achieved the 50 percent concentration level. Additionally, Durner et al. (2004) reported that polar bears in the Southern Beaufort Sea selected ice concentrations greater than 50 percent when it was available during their primary foraging periods in the spring and fall. The use of this metric does not assume that polar bears will not use lower concentrations of ice, only that lower ice concentrations are not preferred. The authors state that this concentration was used as an index of sea ice conditions for use as a covariate in analyzing if there were polar bear demographic relationships. Durner et al. (2007) determined that polar bears in the southern Beaufort Sea select strongly for sea ice over the shallow waters of the continental shelf (see also Durner et al. 2004). Also within the 300 m isobath, ice concentrations in spring and fall move to lower (0 percent) and higher concentrations (100 percent) respectively in a rapid fashion which further discounts the value for concentrations of less than 50 percent since these concentrations are available for only short periods of time. We find the ice index accurately represent polar bear utilization and is appropriate for the objectives of this study.

Comment (43): The sea ice—polar bear relationships presented in the report appear to be on an annual but not cumulative basis.

Response: The results of analysis of the relationship between sea ice and polar bears are presented on both an annual basis as well as projections of changes over time, which describe cumulative effects. Examples of the annual relationship are the deterministic and stochastic population growth rates (these are annual rates). An example of the cumulative effects of the relationship is the projection of relative population size at 45 years.

Comment (44): It is not clear why models were calibrated with an ice free mean of 114 days.

Response: The authors calibrated the model to the mean number of ice-free days for 2000-2005. Other values for a single year or range of years for "observed" values of ice free days during 2000-2005 could have been used for this calibration purpose. The main objective was to establish a known basis for ice-free days for future reference from 2005 outward. This calibrated all the models and produced sea ice projections scaled relative to the observed current (or recent past) conditions.

Comment (45): This report found that between 1979 and 2005, there were 6 of 28 (21 percent) years with "bad" ice conditions and 22 of 28 years (79 percent) with good ice conditions in the Southern Beaufort Sea. Regehr et al. (2007) found that survival was better in good ice years vs. bad ice years that occurred between 2001 and 2006. Based on these findings, is there justification and certainty in predicting into the future 45 years?

Response: We find that there is justification for predicting population status into the future based on results of the modeling effort. The authors evaluated the relationship of good and bad sea ice conditions on polar bear demographics and population growth rates observed during this study. Using this information and the projected sea ice conditions in the next 45 years the authors then evaluated the change in frequency of occurrence of good and bad years into time. Setting the ratio of good to bad years based on current observations would be inconsistent with climatologic research projected by the IPCC GCMs and other recent research reported in the literature. Regarding uncertainty, the authors explicitly identify uncertainty in model covariates and correspondingly also describe uncertainty for the outcomes of the analysis. They projected the future status of polar bears based on a projection of the frequency of good and bad ice years. The approach is consistent with the scientific theories of modeling future conditions, and is an accurate expression of the best available scientific information in developing forecasts for polar bear populations into the future.

Comment (46): The potential for harvest to become largely a form of compensatory mortality is not considered.

Response: The authors considered inclusion of compensatory harvest mortality in the analysis. Density dependence and compensatory mortality (natural or man-caused) were previously evaluated by Derocher and Taylor (1994). They were unable to identify any population of polar bears in which density effects were demonstrated and suggest that changes in cub survival and recruitment observed were most likely caused by environmental fluctuations. They further indicate that no polar bear studies have shown a relationship between density and female condition. In general compensatory factors are less likely to occur for slowly reproducing, long lived species characterized by high rates of survival than for species with short life spans, high reproductive rates, and low survival. We acknowledge in the Factor C analysis in the final rule that density effects from intra-specific stress factors may become greater for populations experiencing nutritional stress; however, we also find that these stressors do not rise to a level that threatens the species throughout all or a significant portion of its range. While there may be relatively small, but unknown compensatory values of harvest, these possible values are overwhelmed by the effects of declining habitat, decreased carrying capacity, nutrition and body condition declines, associated lower survival rates, and projected population declines. Harvesting polar bears from populations that continue to experience loss of sea ice habitat will not have compensatory value for the remaining bears.

Comment (47): Five years of data on tagged females, which are not representative of the population, are not enough data to make future projections.

Response: The data available for the six years of study were the most comprehensive and complete of any time period for this population. There is no evidence to suggest that the large number of adult females tagged during the study were unrepresentative of the population as a whole. We acknowledge that longer-term studies with larger samples would have greater value if they were available. Nevertheless, the data from this study represent the best available scientific information. In order to overcome issues associated with demographic analyses of a long-lived species living in a highly dynamic environment undergoing dramatic changes, the authors tested the results from multiple sets of statistical models, from both deterministic and stochastic demographic models, from stochastic models that do and that do not rely on GCMs for future sea ice scenarios, and from 10 different GCM projections. The limitations of the data set are expressed in the uncertainty in the results, which are fully described in the USGS reports.

Comment (48): The model was altered when it gave unexpected results.

Response: This model was not altered. It was partitioned into two categories based on the outputs and all results were considered.

Comment (49): Capture mortality should be presented as in Rode et al. (2007).

Response: Capture mortality did not affect the results of the analysis. Of over 700 polar bears greater than 2 years old handled one or more times during the study, there was only one handling-related mortality.

Comment (50): Figure 7 appears to have conflicting information regarding the effect of harvest on growth rates that indicates that harvest has less of an effect on populations with a lower initial growth rate than those with higher initial growth rates.

Response: The figure illustrates that proportional effects of harvest were very similar for populations experiencing either lower or higher initial growth rates.

Polar Bears in the Southern Beaufort Sea III: Stature, Mass, and Cub Recruitment in Relationship to Time and Sea Ice Extent between 1982 and 2006 (Rode et al. 2007)

Comment (51): It is important to note that adult body mass was not related to sea ice cover and did not show a trend with time in the Southern Beaufort Sea population from 1982 to 2006.

Response: This comment restates information in the report. From a population dynamics standpoint, the adult age class is less likely to show morphometric changes than either young and growing cubs or sub-adults since adults have already achieved most of their growth potential. The authors evaluated an array of relationships to assess changes in body size, mass, and cub recruitment. It was the array of analyses and relative consistency in direction of the results that provide the basis for conclusions discussed in this report.

Comment (52): Correlation does not by itself prove a causal relationship. The authors should not infer a cause-effect relationship from statistical relationships.

Response: The authors identified and tested hypotheses appropriate for this analysis. They also objectively evaluate appropriate alternative hypotheses to enhance clarity or accuracy of results derived from the analysis. Based on these analyses they clearly present results, some which indicate a relationship to the timing and extent of sea ice in the study area and others which do not indicate a relationship. They then provide discussion and rationale for their conclusions considering the results. We find that all approaches undertaken within this analysis are consistent with appropriate scientific methods, and the conclusions that timing and extent of sea ice affected various morphometric and condition measures of polar bears are appropriate.

Comment (53): There was not a significant decline in the ice metric, as a measure of polar bear habitat in the southern Beaufort Sea, between 1982 and 2005, which counters the entire argument that there is a problem.

Response: The comment that there was not a significant decline in the ice metric used by Rode et al. (2007) to examine relationships with bear size, mass, and condition is correct. However, Rode et al. (2007) did refer to a documented significant decline between 1982 and 2005 in a recently developed ice metric that is based on the availability of optimal polar bear habitat in the southern Beaufort Sea (Durner et al. 2007). In their discussion, Rode et al. (2007) indicate that this improved ice metric was not available at the time that they conducted their analysis. A significant decline in this new ice metric is consistent with the concern that ice habitat availability to polar bears in the southern Beaufort Sea, and other parts of their range, has declined.

Comment (54): The sea ice and polar bear data presented do not seem to support the conclusion that as the sea ice habitat decreases the bear condition may also deteriorate.

Response: The report finds that young males (ages 3-10) exhibited declines in mass and Body Condition Index (BCI) over time and related to ice conditions. In addition mass and skull size of cubs-of –the-year were related to ice conditions. There was a high correlation between the sea ice metric used in this paper with that of Durner et al. (2007).

Comment (55): Repeated measures taken from the same individual bears need to be accounted for statistically.

Response: The authors consulted with a professional statistician regarding the possibility of accounting for repeated measures statistically, but this is difficult to accomplish when only part of the sample is repeatedly measured. It is not possible to capture large numbers of animals more than once in a study such as this. The authors did account for this potential factor to some degree via the capture history covariate. In this covariate analysis the trends in ice and year were examined separately for individuals captured once vs. those captured multiple times. Samples including no repeated measures showed the same relationships as those that were repeated and, therefore, validate the results. The authors note that the capture history variable helped to account for repeated measures of individuals to a degree. The authors do not believe that biases have resulted.

Comment (56): The analysis should include sub-adults and adult bears.

Response: Sub-adults and adults were included in the analysis.

Comment (57): Conflicting data are presented and the variable ice was not related to several parameters.

Response: All results of the analysis were presented and are included within the report and tables. Results presented include those that showed significant effects and those that did not show significant effects. Authors report that not all sex/age classes showed declines over time or with relationships to sea ice. The relationships or absences of a relationship did not vary in direction or rate.

Comment (58): Alternative explanations for observed changes in mass, stature, or body condition, including disease, size, or selective hunting, should be expanded.

Response: The authors indicate that the absence of any indication of disease affecting polar bears at the individual or population level was the reason for not including this factor in the analysis. Regarding size selective harvest of polar bears, the lack of a sport harvest or incentives to take larger bears or bears of different sizes were reasons for not including this in the analysis as stated in the discussion section.

Comment (59): The data reflect relationships of bear condition and habitat condition on an annual basis, thus results are based on annual phenomena and not cumulative effects.

Response: The comment is accurate for the sex/age classes for which no decline was detected over time. It is not accurate for males age 3-10 which showed significant relationships between mass, condition, and size for the ice metric and year. Thus, changes in sea ice did have a cumulative effect on the size, mass, and condition of young males.

Uncertainty in Climate Model Projections of Arctic Sea Ice Decline: An Evaluation Relevant to Polar Bears (DeWeaver 2007)

Comment (60): The report incorrectly suggests that B1, A1B, and A2 scenarios concerning CO_2 emissions are not stabilized and represent cases where specific policies are not made to limit global warming.

Response: This comment is in apparent reference to page 18 of DeWeaver (2007): “Zhang and Walsh consider three different IPCC forcing scenarios, B1, A1B, and

A2, in which CO_2 concentrations are controlled and stabilized at 549, 717, and 856 ppm, respectively, by the year 2100 (IPCC 2001, Appendix 2)." The "forcing scenarios" mentioned by DeWeaver come from the IPCC's Special Report on Emissions Scenarios (SRES), published in 2000, and can basically be thought of as trends in GHG concentrations over time based on assumptions on how societies, economies, and energy technologies are likely to evolve in the 21st century. These scenarios have been used to estimate a range of future emissions that affect the climate. The scenarios most commonly used in current-generation climate models (i.e., models used in the IPCC Fourth Assessment Report (AR4)) are B1, A1B, and A2, which represent 'low' (B1), 'medium' (A1B) and 'high' (A2) scenarios with respect to GHG emissions/ concentrations in the 21st century. Each emission scenario follows a specific trajectory; some trajectories are declining by 2100, some are increasing. Specifically, the B1 scenario has a declining trajectory by 2100, the A1B is stable or very slightly declining by 2100, and the A2 has an increasing trajectory (see Figure 3 in the IPCC Special Report, Emission Scenarios: Summary for Policymakers (2000)). None of the SRES emissions scenarios includes specific policies to mitigate emissions of GHGs (although several scenarios do have declining GHG trajectories due to other factors). DeWeaver (2007) and other climate modelers, as well as international scientists interpreting the results of climate modeling, including Zhang and Walsh (2006), have appropriately used and interpreted the SRES emissions scenarios.

Comment (61): The 10 GCMs used to predict future conditions are not an appropriate subset of models.

Response: Because a focus of the USGS work was to make predictions about the possible future rangewide status of polar bear populations and the status of optimal polar bear habitat in the polar basin, they were challenged with how best to use the IPCC AR4 GCMs results that vary in how well they project sea ice extent through the 21st century. In order to reduce the uncertainty associated with using the GCM outputs, USGS selected 10 models based on the concordance between their simulations of summer sea ice extent from 1953-1995 and the observational record of sea ice extent for the same period. Specifically, DeWeaver's (2007) ensemble included only those models for which the mean 1953-1995 simulated September sea ice extent was within 20 percent of the observed September sea ice extent for the same period. The USGS recognized that using models, which performed poorly in simulating the present could not be expected to perform well at time steps farther into the future. It makes sense to focus on those models that give credible results and eliminate those that are clearly biased in one direction (simulations result in too little ice compared to observations) or the other (simulations result in too much ice compared to observations). Overland and Wang (2007a), for example, state that their experience, as well as the experience of others, suggests that one method to increase confidence in climate projections is to constrain the number of models by removing major outliers by validating historical (20th century) simulations against observations. They state that this requirement is especially important for the Arctic. Other scientists have used similar approaches (e.g., Stroeve et al. 2007).

Comment (62): The forecasts are not conservative and deviate from long-term trends.

Response: DeWeaver (2007) reviewed key recent studies, including those by Zhang and Walsh (2006), Arzel et al. (2006), and Stroeve et al. (2007), with a focus on how well the climate simulation ensemble results reported in those papers matched observed sea ice trends in the 20^{th} century. DeWeaver (2007) reports that both Zhang and Walsh (2006) and Arzel et al. (2006) found generally good agreement between annual-mean sea ice area observation and simulation ensemble means. Stroeve et al. (2007) found that September sea ice extent in their ensemble mean was substantially smaller than the observed trend for two time periods – 1953 to 2006 and 1979 to 2006. The general agreement between ensemble simulation results and the observational records (or, in the case of Stroeve et al. (2007), the conservative simulation results) affords confidence that future projections of sea ice changes using the same ensembles are likewise accurate or even conservative, not vice versa as this comment suggests. Furthermore, both DeWeaver (2007) and Overland and Wang (2007) employed objective selection criteria to identify the ensemble of models that provide the most accurate projections of future Arctic climates by eliminating models that are too biased in one direction or the other. This approach has been recommended by other authors as well (e.g., Holland and Bitz 2003; Wang et al. 2007; Stroeve et al. (2007)). Using the results from the subset of models selected in this way further increases confidence in the future projections.

We also note that long-term trends do not necessarily provide a sound and reliable basis upon which to make future projections. Various climate mechanisms, in particular the sea-ice albedo feedback mechanism, may cause climate and sea ice changes to deviate, perhaps radically, from long-term trends. In particular we note the simulation results reported by Holland et al. (2006), which indicate that abrupt sea ice declines may occur around 2040.

Comment (63): The final models predict sea ice conditions that are no worse than those experienced annually for the stable populations of Southern Hudson Bay and Davis Strait where there is an ice free period 60 percent of the time.

Response: We do not believe that it is scientifically sound to make a direct comparison of the Southern Hudson Bay and Davis Strait populations, which are accustomed to and have behaviorally adjusted to a seasonally ice-free environment, with populations in the Arctic Basin, which are accustomed to live with sea ice more or less year-round, or with populations in the Canadian archipelago, which also have differences in their life history that may be related to sea ice. Additionally, while population declines have not been documented in the Southern Hudson Bay population, the bears in that population are showing evidence of declining body condition similar to what was recorded for polar bears in Western Hudson Bay immediately prior to documenting a population decline in Western Hudson Bay. Two recent reports compare polar bear body condition for two periods of time 1984-1986 and 2000-2005 in the Southern Hudson Bay population (Obbard et al. 2006; Obbard et al. 2007). The authors found that the average body condition for all age and reproductive classes combined was significantly poorer for Southern Hudson Bay bears captured from 2000 to 2005 than for bears captured from 1984 to 1986. Similar information is not available for Davis Strait bears. Thus, we do not believe that the available empirical evidence supports the contention in this comment.

Comment (64): Climate models have limited capabilities to predict the future due to all the variability in the system. Limit is about 10 years with excellent climate data that go into the models.

Response: This comment refers to the statement on page 3 of DeWeaver (2007): "Even if climate models contained a perfect representation of all climate system physics and dynamics, inherent unpredictability would prevent us from issuing detailed forecasts of climate change beyond about a decade." In this statement, DeWeaver is referring to the issuance of detailed forecasts (or predictions) that particular events will occur at specific times or at specific magnitudes. This would not be an appropriate use of climate models. Climate models are not the same as weather forecasts in that they do not attempt to forecast what the weather will be like at a specific point in the future given what the weather is now.

Climate models incorporate laws of physics which regulate the chaotic fluctuations in the natural climate system. They are initiated with the climatology of the distant past (usually around 150 years ago) and run forward in time. If the models are parameterized correctly, they should closely simulate the major patterns, such as sea ice fluctuations, in observed and future climate, but they are not expected to exactly match the observed record on a yearly or even decadal basis owing to the natural climate variability that the models intrinsically strive to simulate. The observed record is but one realization of the possible model outcomes which theoretically could have been observed. Any particular model run provides a different realization, and another model run would provide still yet another realization. Any given model run, if parameterized correctly, should be able to project the trend into the future, but would not necessarily project that certain events would occur at certain time frames.

Therefore, within a model run, it is appropriate to look at climate or sea ice projections in terms of the mean and range of the trends they project. It would not be appropriate, however, to try to interpret apparent differences between successive decades as precise forecasts of what was to happen in each of those decades. For example, it would be appropriate to interpret an ensemble of climate models as suggesting that during the next 30 years, sea ice extent will begin to decline at an accelerating rate. Almost every recent IPCC AR4 GCM suggests that. It also would be appropriate to conclude from the model projections that short periods of accentuated ice decline will occur during the next 30 years. Most of the models show periods of gradual decline in sea ice extent punctuated by sudden periods of more rapid decline. It would be inappropriate, however, to conclude that the periods of more rapid decline will occur in a particular year or even in a particular decade. It is precisely because of this inherent variability that climate modelers tend to rely on ensembles of simulations to project future climate change. Ensembles can include the simulation results from several models, averaged to produce a "mean" value for a given parameter such as temperature, sea ice extent, or sea ice area. Ensembles can also include different simulations run through the same model, with slight differences in internal variability programmed into each model run. These different runs then can be averaged to produce a "mean" value for the parameter of interest. By considering the results of multi-model ensemble simulations as well as results from single-model simulations, we gain additional confidence in climate change projections for a greater period in the future. We are confident in model simulation projections for the "foreseeable future" as defined in this rule (45 years, or until approximately 2050-2055).

Comment (65): The report used a flawed procedure when selecting which GCM models to use to project trends in polar bear habitat. This is due primarily to the high uncertainty and natural variability about Arctic region simulations (arctic clouds, albedo effects, winds, Arctic Oscillation) and high model variation in the simulation of ice pattern, thickness, seasonal dynamics, movement, longevity, and export.

Response: As discussed above, USGS used appropriate procedures in selecting the GCM models used to develop projections of polar bear population trends. As stated previously, we believe it is scientifically sound to focus on those GCMs that best simulate sea ice conditions for the observational period. This is done by validating historical (20th century) simulations against 20th century observations of September sea ice extent or area, and eliminating those models that are clearly biased in one direction (simulations result in too little sea ice compared to observations) or the other (simulations result in too much sea ice compared to observations). Not only did DeWeaver (2007) recommend this approach for the USGS work, but other scientists such as Overland and Wang (2007a) and Stroeve et al. (2007) have used very similar approaches. Thus, we are confident in this approach.

The current-generation climate models account for a wide range of natural phenomena such as the AO (also called the NAM), the NAO, and the ENSO. Some models do better than others at simulating these phenomena, while some phenomena such as cloud feedback remain difficult to model successfully. These are all reasons to utilize the results from an ensemble rather than a single simulation run of a single model. Additional, more-detailed information on climate models and their evaluation can be found in Chapter 8 of the IPCC AR4 (IPCC 2007, pp. 591-662). The Executive Summary of Chapter 8 provides a worthwhile summary of current confidence in the ability of climate models to simulate natural variability:

> There is considerable confidence that Atmosphere-Ocean General Circulation Models (AOGCMs) provide credible quantitative estimates of future climate change, particularly at continental and larger scales. Confidence in these estimates is higher for some climate variables (e.g., temperature) than for others (e.g., precipitation)…Progress in the

> simulation of important modes of climate variability has increased the overall confidence in the models' representation of important climate processes.

We agree with the assertion that models "provide credible quantitative estimates of future climate change, particularly at continental and larger scales," particularly when the results of multiple ensemble simulations of the same parameters (e.g., sea ice decline) are considered.

In addition, two recent papers (Raupach et al. 2007; Canadell et al. 2007) indicate that the growth rate of CO_2 in the atmosphere is increasing rapidly. According to Raupach et al. (2007) the emissions growth rate since 2000 was greater than for the most fossil-fuel intensive of the IPCC's SRES emissions scenarios (the A1F1 scenario). Thus, the trajectories of the B1 and A1B emissions scenarios are looking increasingly conservative in relation to observed trends.

Comment (66): There should be justification as to why more than one greenhouse gas forcing scenario was not included in the selection criteria.

Response: The A1B scenario was chosen since it most accurately reflects what is occurring today and what can conservatively be projected for the future. Recent reports indicate that CO_2 loading is not decreasing but instead is increasing. Thus, at the moment, there is no indication that emissions will lessen in the near future. Furthermore, the foreseeable future 45-year time frame will be affected by emissions already loaded into the system or projected to be added in the next decade or two. Additionally, most models used in the IPCC AR4 utilized SRES emissions scenario A1B. This choice was based on two principal reasons. First, the number of different emissions scenarios that can be run on a given climate model is constrained significantly by time and cost considerations, because of the complexity of the models and the vast amount of data used in the simulations. Second, the A1B emission scenario is considered a "middle-of-the-road" scenario, making it less likely to simulate extremes in climate change. Because most AR4 models utilized the A1B scenario, it was chosen so there would be a large enough sample to assess the spread of possible outcomes (DeWeaver 2007). We note that both Overland and Wang (2007) and Stroeve et al. (2007) used results from A1B simulations in their analyses, reinforcing the acceptance of this approach (i.e., using the A1B scenario) within the scientific community.

Comment (67): The report should present the entire range of results.

Response: The results presented are the most accurate, and those that most reasonably can be expected to occur. Presenting a wider range of outcomes clouds the issue with projections that are unlikely to be realized and are less well correlated to existing observed conditions. We have confidence in the selection criterion used by DeWeaver (2007), who notes on page 21 that "The selection criterion…should represent a balance between the desire to focus on the most credible models and the competing desire to retain a large enough sample to assess the spread of possible outcomes." It is desirable to eliminate from consideration those models that do not adequately simulate historical (20th century) sea ice conditions (e.g., September sea ice extent).

Predicting the Future Distribution of Polar Bear habitat in the Polar Basin from Resource Selection Functions Applied to 21st Century General Circulation Model Projections of Sea ice (Durner et al. 2007)

Comment (68): The report excludes Archipelago Ecoregion, Seasonal Ecoregion, East Greenland, and the optimal polar bear habitat for Davis Strait and Southern Hudson Bay.

Response: The Durner et al. (2007) study investigated polar bear populations throughout the polar basin which included the Divergent and Convergent Ecoregions. The Seasonal Ice and the Archipelago Ecoregions were not included because data to develop the model for these ecoregions were not available. Further, due to behavioral differences of polar bears in the Seasonal Ice and Archipelago Ecoregions, it is not appropriate to apply the pelagic model to these ecoregions.

Comment (69): The climate information stated in the GCM overestimates the ice extent for both the 20th and 21st century.

Response: The 10 GCMs were chosen based on their ability to best represent the average sea ice conditions observed from from 1953-1995. The choice to use these 10

GCMs was reaffirmed by several studies. Assessment of 20th century simulations of sea ice compared to observations was done by Arzel et al. (2006), Stroeve et al. (2007), and Zhang and Walsh (2006). Both Arzel et al. (2006) and Zhang and Walsh (2006) compared annual mean ice area in a 14-model ensemble and found good agreement between the ensemble mean and actual observations. In contrast, Stroeve et al. (2007) obtained results indicating that the 18-model ensemble overestimated sea ice extent for their period of analysis. While the results by Strove et al. (2006) imply a lack of concordance, Holland (pers. comm., cited in DeWeaver et al (2007)), cautioned that differences between the studies were due to different analysis periods and the use of sea ice extent versus sea ice area. The methods and results of DeWeaver (2007), however, are similar to those of Zhang and Walsh (2006) and Arzel et al. (2006). DeWeaver (2007) identified 10 models that fit the selection criterion (i.e., model simulation that were within 20 percent of actual observations for 1953-1995). With respect to the 21st century it is not currently possible to know whether the model overestimates sea ice extent. Lastly, Durner et al. (2007) acknowledge that the GCMs appear to be conservative, and may, therefore, underestimate the realized rate of 21st century sea ice trends.

Comment (70): Durner et al. (2007) used a threshold of 15 percent to describe the lower end of ice concentration used by polar bears but other reports use 50 percent as the lowest concentration; this discrepancy should be justified in context with the other reports.

Response: Each report addressed specific questions that guided the choice of habitat parameters. The reports dealing with population projections (Hunter et al. (2007); Regehr et al. (2007); Rode et al. (2007), etc.) developed models of population indices based on various parameters. One of those parameters was a metric of habitat, which they set as 50 percent sea ice cover (where areas with less than 50 percent were non-habitat and areas with greater then 50 percent were good habitat). Their choice of a 50 percent threshold was based on prior research of polar bear/sea ice relationships (e.g., Stirling et al. 1999, Durner et al. 2006). In other words, the 50 percent sea ice metric was already set for them.

The goal of Durner et al. (2007), however, was completely different from the population projections. Durner et al. (2007) attempted to quantify, from a set of habitat covariates that were available to all bears in the target polar bear population, those covariates and the level of those covariates that best explained the distribution of polar bears in the pelagic realm of the polar basin. In other words, Durner et al. (2007) built models (i.e., Resource Selection Functions, or RSFs) that provided an index of the relative probability of occurrence of polar bears across the Arctic Ocean. To do so Durner et al. (2007) were required to include all available sea ice habitats, including passive microwave pixels with sea ice concentration as low as 15 percent, to determine what sea ice concentrations were selected by polar bears. The results of Durner et al. (2007) were similar to other research that demonstrated selection for sea ice concentrations greater then 50 percent and very low selection for sea ice concentrations at

15 percent. The results of Durner et al. (2007) also support the choice of other reports (e.g., Hunter et al. (2007); Regehr et al. (2007); Rode et al. (2007)) to use 50 percent as a critical minimum sea ice threshold.

Comment (71): Reductions in optimal habitat, which represent 20 percent of the RSF-valued area, results in large areas of "non-optimal" habitat, which may be used by bears particularly if habitat quality increases or bears adapt. The approach used by the authors assumes that polar bears in the future will select habitats in the same way as they did between 1985 and 1995.

Response: A consistent set of variables that would be applicable to the entire ice region were selected. The modeling used in this report was based on empirical data. There are currently no data to predict how polar bears will modify their behavior in response to a reduced sea ice environment and thus this cannot be accurately modeled. The fact that polar bears selected optimal habitat with the declining sea ice conditions from 1995-2006 suggest that the model performed well with respect to changing environmental conditions and that polar bears remained consistent in their selection of sea ice habitat despite evidence of changing sea ice conditions. The main point is that non-optimal habitats are used to a lesser degree for a reason, which is important in evaluating future welfare and condition, and there was no evidence of a shift in habitat preferences with changing sea ice conditions between the two decades (1985-1995 and 1996-2006).

Comment (72): There is a need to include a covariate reflecting consistent access to carrion.

Response: Carrion represents only a minor contribution to the nutritional intake for polar bears and is not anticipated to provide significant value for the species across its range in the future. Though certain localized areas may experience some seasonal benefits from carrion, such as the remains from bowhead whale subsistence hunting, the overall contribution to the species will be minimal. For example, in the southern Beaufort Sea, whale carcasses at butchering sites are used by less then10 percent of the polar bears in that population. Therefore, the low rate of occurrence, unpredictable nature of marine mammal carcass deposition (frequency, location, and numbers), and lack of quantitative data do not warrant inclusion of this covariate in the model.

Comment (73): The Arctic Oscillation may have made the 1980s cooler and the sea ice more extensive that the 100-year mean. This information should be incorporated. Alternatively, why this was not considered in the GCMs used should be clarified.

Response: Arctic sea ice data for the 20th century do not support the assertion that sea ice extents during the 1980s were anomalously higher than the long-term average. Furthermore, models chosen by DeWeaver (2007) are based on climate data from 1953-

1995 and during this period there were several Arctic Oscillation events. Thus, it is incorrect to say that the effects of the Arctic Oscillation were not included.

Comment (74): Regehr et al. (2007) have demonstrated (Figure 3) that polar bear populations have survived years with longer ice-free periods than what was used to project declines in survival rates for this population in Durner et al. (2007).

Response: The authors used quantitative data to develop the Resource Selection Function models, but made no projections of population decline. The issue addressed in the survival analysis of Regehr et al. (2007) is not whether populations have persisted through years with long ice-free periods, but whether the survival of individuals is lower during those years.

Predicting Movements of Female Polar Bears between Summer Sea Ice Foraging Habitats and Terrestrial Denning Habitats of Alaska in the 21st Century: Proposed Methodology and Pilot Distribution of Polar Bear habitat in the Polar Basin from Resource Selection Functions Applied to 21st Century General Circulation Model Projections of Sea ice (Bergen et al. 2007)

Comment (75): The assumption that polar bears are at carrying capacity is wrong. Consequently the results from the carrying capacity model are inaccurate.

Response: The report does not make assumptions regarding carrying capacity and explains at length how the term was defined and applied. Although the application of the term carrying capacity differs from the classical definition, it was well described and its use was appropriate for the analysis conducted. The carrying capacity model accurately portrays trends in polar bear population based on their relationship (density) to sea ice. See also response to Comment 93.

Comment (76): The assumption that polar bear numbers are directly proportional to the amount of preferred ice is wrong.

Response: The report does not make assumptions that polar bear numbers are directly proportional to the amount of preferred ice.

Comment (77): The hypothesis that denning success is inversely related to the distance that a polar bear is required to travel to reach denning habitat is questionable. Rather it should indicate that body condition is inversely related to the distance traveled.

Response: We have reviewed the report's general discussion on denning success, and conclude that the authors have correctly included an assumption that reproductive success is based in part on body condition (see Atkinson and Ramsay 1995) and that increases in distance traveled by pregnant female bears will negatively impact their body condition and, potentially, their reproductive success. We note that a more inclusive term that would incorporate the body condition of the female would be reproductive fitness. This term accounts for the condition of the adult female as well as the net production of cubs to the population. Adult female survival, as a result of body condition, during these long migrations to denning areas is likely to be an important factor with respect to population dynamics.

Comment (78): Pre-1979 data are needed to augment "earlier records to assess the longer term patterns of sea ice extent and duration".

Response: The Service recognizes the completeness of the study and notes that the authors have provided an acceptable reference frame and time span to analyze past and current movement patterns of polar bears. While we acknowledge that the inclusion of pre-1979 data, were they available, could provide additional insight into distances traveled, we do not believe that the conclusions reached by this report would be significantly altered. Regardless, there are no pre-1979 data from which to make this assessment.

Comment (79): It is not clear why, if there are a greater proportion of dens on land, this pattern would continue into the future. It is possible if bears do not have access to land for denning due to longer periods of open water, they will den more frequently on the ice.

Response: This report looked specifically at the distance a hypothetical bear would have to travel to return to current preferred habitat. As such it provides a model upon which to gauge possible responses by, and impacts to, bears. Support for the results in this report are provided by Fischbach et al. (2007) who evaluated changes in the distribution of polar bear maternal dens between 1985 and 2005 from the Southern Beaufort Sea population, using satellite telemetry. They determined that the distribution and proportion of polar bear maternal dens on pack ice declined from 62 percent in 1985–1994 to 37 percent in 1998–2004 and, among pack ice dens, fewer occurred in the western portion of the southern Beaufort Sea after 1998. It was outside the scope of the Bergen et al. (2007) report to anticipate how polar bears might otherwise respond or modify their behavior in response to future reductions in sea ice. However, it is not believed that polar bears will be very successful denning on the remaining ice because the quality of that ice may be less stable and it may be far removed from productive forgaing habitat.

Comment (80): Several assumptions may not be correct, e.g., that (1) increased travel distances will reduce body condition; and (2) den site fidelity is extremely high and polar bears will be forced to travel long distances from the ice platform.

Response: This report provided insight into the possible distances bears would have to travel to return to a preferred denning site in northeast Alaska. As indicated by the report's title, it presents a prototype methodology and preliminary results and as such, we feel the report, and its limited conclusions are appropriate for use in our analysis. The energy requirements associated with walking or swimming over ever increasing distances to return to preferred denning habitat, coupled with a polar bears' limited ability to successfully hunt and consume prey in the open water, or walking long distances to return to preferred denning habitat, will not improve body condition. Furthermore, numerous studies as referenced by the authors have documented den site fidelity in this species. While we recognize that in the future bears may abandon current denning areas in favor of others, the scope of Bergen et al. (2007) was to quantify changes with respect to a traditional denning area.

Comment (81): This report doesn't consider the option that polar bears may go to land during the summers and thus be in close proximity to land denning areas in the fall and early winter.

Response: We agree that this report did not consider the possible alternatives to traveling ever increasing distances associated with changing ice conditions. The focus of this report was to provide an understanding of the conditions polar bears would face given our current understanding of bear behavior and anticipated effects of the changing sea ice environment. We recognize that in the future there are possible alternatives to returning to current preferred denning habitat; however, such an analysis is beyond the scope of this study.

We also offer the following information to clarify the possibility that bears may redistribute to land areas during the summer and be in proximity to suitable denning habitat. This behavior is known to occur for populations that are associated with seasonally ice free conditions, e.g. Western Hudson Bay and Southern Hudson Bay. For Western Hudson Bay bears that are spending longer periods of time on land due to later formation and earlier departure of sea ice, the consequence has been reductions in body condition, recruitment, and survival that have translated into population reductions over time. Thus, it is unlikely that this behavior (seasonal use of land areas) would benefit polar bears in other regions. Furthermore, autumn coastal surveys have shown that fewer than 8 percent of the polar bears of the southern Beaufort Sea population use land during summer (Schliebe et al. in press), and no trend of increasing use from 2000-2006 has been detected. Therefore, while the southern Beaufort Sea polar bears may shift to a Hudson Bay summer strategy in the future, no evidence is available that this is occurring, and there is no evidence that if it were to occur that it would be a successful strategy.

Forecasting the Range-wide Status of Polar Bears at Selected Times in the 21st Century (Amstrup et al. 2007)

Comment (82): There is no justification to divide the range of the polar bear into four ecoregions.

Response: The report describes in detail the justification and physiographic distinctions between the four ecoregions based on sea ice patterns, habitat use by polar bears, and predicted fate and effects of ice. Each ecoregion is characterized by a general type of seasonal ice pattern and longterm fate. As a result, polar bears were expected to be affected differently between ecoregions. The findings described previously in the proposed rule regarding the timing and magnitude of effects of sea ice loss for various populations throughout the Arctic parallels to a great extent the ecoregion designation and analysis presented by USGS.

Comment (83): The report should not use the four ecoregion designations as the Service did not decide to identify Distinct Population Segments (DPS) in its proposed rule.

Response: The use of four ecoregions provided additional ecological insight regarding the differences among areas occupied by polar bears for use in projections of the future of polar bears within and among the ecoregions. The ecoregions were not used to designate DPSs.

Comment (84): The modeling assumes a linear relationship between sea ice extent and polar bear numbers.

Response: The carrying capacity model (CM) does assume a linear relationship between sea ice extent (area) and numbers of polar bears. The numbers of bears in each ecoregion were based on the IUCN/Polar Bear Specialist Group population estimates referenced in the status assessment of circumpolar polar bear populations from the 2005 PBSG working group meeting (Aars et al. 2006). The CM incorporates sea ice information from 10 widely-accepted GCMs, and also accounts for habitat quality of sea ice by considering the resource selection values of ice (predicated on the work of Durner et al. (2007)). The linear/deterministic relationship was then contrasted with the more complex Bayesian Network (BM) modeling approach which did not assume a linear relationship between sea ice and polar bear densities. We find that the approach is consistent with sound scientific methods and incorporates the best available scientific information into the analysis.

Comment (85): The Bayesian Network Model (BM) has input from "only one expert" and therefore the validity of the model was questioned.

Response: While the BM model had direct input from one polar bear expert this individual had extensive polar bear research experience as well as an extensive background on the abundant literature available on polar bears and a working collaboration with numerous experts in the field. In addition the BM report was reviewed by four scientists not previously involved with the model development. These peer reviewers had different perspectives and expertises, representing had appropriate background and expertise one or more of the following topics: BM modeling, modeling in the context of endangered species decisions for marine mammals, and polar bears. We recognize the preliminary nature of this model. The BM analysis is a preliminary effort that requires additional development. The current prototype is based on qualitative input from a single expert, and input from additional polar bear experts is needed to advance the model beyond the alpha prototype stage. There are also uncertainties associated with statistical estimation of various parameters such as the extent of sea ice or size of polar bear population. In addition, the BM needs further refinement to develop variance estimates to go with its outcomes. Because of these uncertainties associated with the complex BM, it is more appropriate to focus on the general direction and magnitude of the projected outcomes rather than the actual numerical probabilities associated with each outcome. Despite these limitations, we also recognize the contribution of expert opinion that essentially evaluates the over-arching issue of the effect of a diminished sea ice environment on polar bears and provides a documented and integrated assessment of potential outcomes. As such, the information on the general direction and magnitude of the projected outcomes is a useful contribution to the overall weight of evidence and likelihood regarding changing sea ice, population stressors, and effects. The information and results of this effort were parallel to and consistent with previous hypotheses that were later demonstrated for two populations with extensive data extending over a lengthy period of time, the Western Hudson Bay population and Southern Beaufort Sea population. The BM results are generally consistent with the 2006 finding by the World Conservation Union (IUCN) that polar bears are vulnerable to extinction based on loss of sea ice habitat projected into the future. This finding was based on the independent evaluation by the PBSG comprised of polar bear scientists from all Arctic countries with polar bears within their jurisdictions.

Comment (86): The vast array of ice types and conditions used by polar bears today vary from population to population and demonstrates the adaptability of polar bear to survive. The present and past survival of polar bears with ice habitat less than 50 percent should be incorporated into the models.

Response: We are unaware of any data indicating that sea ice habitats of less than 50 percent aerial coverage are important to polar bears. A common denominator throughout all populations is that polar bears need sea ice as a hunting platform. To date, studies document that polar bears prefer and are predominantly found in areas where the ice concentration is at least 65 percent during the summer months (Durner et al. 2007), and in areas of higher concentration during the winter. This study incorporates the best available information on the relationship of polar bears and sea ice habitat and projects the effects of changes to sea ice concentrations at various points in time for four ecoregions on polar bear populations in those ecoregions. The model assumes that polar bears will not thrive in low concentrations of sea ice because there are no data available to suggest that polar bears will use sea ice in concentrations of much less than 50 percent.

Comment (87): A comment disagreed with the exclusion of the entire Arctic Basin from the analysis and indicates that three major sub-sea ridges traverse the central arctic basin.

Response: The entire Arctic Basin was not excluded from the analyses. The only area excluded from the analyses is the central portion of the Arctic Basin that is extremely deep and overlays vertically stratified and largely unproductive waters. Years of data from satellite tracking studies for multiple populations indicate that polar bears selectively exclude this area from their activity and movement patterns and few if any polar bears are found as year-round residents of this portion of the Central Arctic. It is important to note that none of the hundreds of satellite-collared polar bears have exhibited year-round fidelity to residency in this area. In addition, the three ridge systems that traverse the central Arctic basin all occupy water depths that are significantly deeper than the 300 m depths of the productive continental shelf, and all are encompassed by the deeper basin waters.

Comment (88): The results of models are based only on the loss of summer ice. There is too much emphasis placed on the effects of sea ice loss during the summer season. It is not clear if carrying capacity is defined primarily by summer sea ice conditions and not ice conditions during other seasons of the year. If winter conditions contribute to the ability of bears to withstand the effects of summer sea ice loss then year-round conditions may also be important.

Response: The carrying capacity model (CM) was designed to reflect changes in average annual sea ice cover. Fluctuations in seasonal ice coverage were not addressed, but were clearly described, and explained as one of the shortcomings of the model. The authors identified this as a constraint or limitation of the model and offered the Bayesian Network Model (BM) approach in order to address the limitations of the CM, including the inability to evaluate sea ice conditions seasonally. The BM incorporated a more detailed understanding than the CM of the influence of seasonal ice changes on the future status of polar bears; it also addressed other stressors and their interactions with polar bears. Although the BM analysis is a preliminary effort that requires additional development, the BM results are generally consistent with the results of longterm studies (i.e., Western Hudson Bay) and GCM models that the length of summer period without sea ice appears to be the major factor affecting survival and reproductive success. This is because the spring and summer period is when seals are most available and accessible and the greatest proportion of the nutritional energy for use throughout the year is accumulated and stored as fat. Thus, loss of access to seals in late spring and summer will have a significant negative effect on the energy required for survival and reproduction. Neither model, however, was limited to only the consideration of summer ice conditions.

Comment (89): The application of information from one population, within the context of the ecoregion designation, to others when population estimates and status for other populations were undetermined or unknown is incorrect; using this presumption allows for development of "an unnecessarily negative trend."

Response: This statement is incorrect. We believe it is appropriate to forecast what might occur to multiple polar bear populations with an ecoregion based on what we know is occurring to one population. Polar bears have the same basic ecological requirements, exhibit similar relationships to these ecological requirements, and are therefore expected to respond to environmental perturbations in a similar manner. Since the ecoregions are defined, in detail, by current and anticipated sea ice conditions, polar bears throughout these ecoregions are expected to respond in a similar fashion to changes in ice conditions. We find the rationale for this conclusion to be supported by scientific information, and to be a valid application of knowledge regarding the determination of status for populations experiencing similar environmental conditions. In the case of the southern Beaufort Sea and the polar basin Divergent ecoregion as a whole, it is possible that other polar bear populations in this ecoregion may be experiencing even more severe impacts than the Southern Beaufort Sea population because they have been subject to even greater losses of sea ice than the southern Beaufort Sea. Forecasting the effects of ice loss on other polar bear populations in the polar basin Divergent ecoregion based on what we know about the southern Beaufort Sea may actually underestimate the impacts.

Comment (90): The Bayesian Network model (BM) is not peer reviewed

Response: This report, as well as the other eight USGS reports, was peer reviewed; comments from peer reviewers are available upon request.

Comment (91): The conclusions of extinction within certain ecoregions are an overstatement of the results.

Response: The modeling results for polar bear populations in each ecoregion are projections of relative probabilities of each of five possible outcomes: (1) larger = more abundant than in the starting year and distribution at least the same as present; (2) same = numerical and distribution responses are similar to the present situation; (3) smaller = reduced in numbers and distribution: (4) rare = numerically rare but occupying similar distribution, or reduced numerically but spatially represented as transient visitors; and (5) extinct = numerically absent or distribution extirpated. The relative distribution of probabilities for each possible outcome conveys the degree of uncertainty. Outcomes in which one state has an overwhelming majority of the probability are more certain than outcomes in which the probability is spread more evenly among different states. The important point from this analysis is that the directional trends and increasing probability of outcomes provide support for the conclusions regarding future status. The conclusions are based on a systematic effort to quantify future status. Model construction, structure, and inputs are transparent and well documented and the results are accurately reported.

Comment (92): There is a need for data, information, and citations for assumptions about bear avoidance and impacts of oil and gas development.

Response: The report includes information on the definition and selection of model parameters as well as citations that serve as the basis for the parameterization. Relative rankings for parameters are presented in the report appendices. Additionally, all references and appropriate explanations are included in the report for all assumptions and the citations are provided in the References Cited section.

Comment (93): The models assume that present day polar bear populations are at carrying capacity without data to support this assumption.

Response: This is an inaccurate interpretation. The authors used current population estimates and sea ice habitat extent to calculate polar bear densities in each ecoregion, which they defined as carrying capacity for that ecoregion. While this clearly explains how the term 'carrying capacity' is used, a more useful or understandable term could be "density capacity." The definition used was not intended to convey the classical understanding of the term carrying capacity. We find that the term has been defined for use in this analysis and is accurate and supportable as defined. We further find that the term is akin to, but not the same as, the classical definition of carrying capacity.

Comment (94): The Bayesian Network model (BM) assumes independence of input nodes; this report does not seem to adequately account for a possible co-linearity effect.

Response: The Bayesian Network Model (BM) used input variables that were assumed to be independent. Tests of correlations between inputs determined a low to moderate degree of correlation of the input nodes. Therefore co-linearity was determined not to be an issue. Further, the BM was run by specifying values of each input node. Therefore any possible co-linearity that may have occurred if inputs were allowed to vary on their own was overshadowed by use of independent values input without regard to values in each of the other input nodes.

Comment (95): The use of the deterministic model is not supported because it failed to account for the following: (1) seasonal nature of the sea ice; (2) stabilizing or destabilizing predator-prey feedback loops; (3) impacts of anthropogenic disturbance (pollution, increased shipping traffic, bear-human interactions); (4) importance of coastlines and the Canadian archipelago for refugia; and (5) probable future distributions.

Response: The deterministic CM model is intended to be a simplistic presentation of polar bear—habitat relations to develop future range-wide population projections. The simple single variable deterministic approach was provided intentionally to contrast with the more complete, multiple variable BM. The BM is a complementary approach that includes the detailed factors in a complex model presentation. Previous responses regarding the design and objectives for the deterministic carrying capacity model provide additional clarification.

Comment (96): It is questionable whether the BM model provided sufficient sensitivity within the context of ecological feedbacks to accurately account for predator-prey dynamics and the potential for increased prey availability associated with reductions in the sea ice.

Response: The BM model incorporates predator-prey interactions and the potential for an initial increase in seal availability based on increased primary productivity due to warmer waters. However, this initial productivity is not believed to be sustained in the longterm due to eventual loss of sea ice required by the seals for molting and birthing. The model also includes the potential influences of alternative terrestrial prey providing equivalent nutritional values to offset the loss of ice seals. In addition, the model considers and incorporates the role and values of ice as a hunting platform for polar bears. The fragmentation and lower concentrations of sea ice, comprised primarily of annual ice, greater expanses of open water, increased movements for hunting and increase swimming required for travel in an ice diminished environment were included in model parameterization and explained. In summary, predator-prey dynamics have been considered in relationship to reductions in sea ice and that the considerations and determinations are well founded and based on research findings, observations, and inferences regarding these relationships. Corroborating information suggesting significant value of alternate prey either in the form of different seal species (spotty distribution, not present in much of the Arctic, and subject to effects similar to ringed seals regarding a diminished ice environment) or terrestrial prey items is unavailable or transitory and thus their value is discounted for the purpose of multi-decadal projections.

Comment (97): The model fails to predict where ringed seals, the major prey base for polar bears, will be distributed when ice has receded north of the continental shelf.

Response: See the response above. In addition, the distribution of ringed seals is considered implicitly in the model, which notes that seals are pelagic (live in the open water environment) during the summer and in ice-free regions. Polar bears are unable to hunt in the open water and therefore, seals are unavailable as prey during these periods. Additional factors of a changing sea ice environment may also effect not only the distribution of ringed seals but also recruitment and survival of ringed seals into populations. These factors include: earlier spring melt periods, later fall freeze-up, and an increased occurrence of rain-on-snow events.

Comment (98): The model is biased by excluding Factor D, the inadequacy of existing regulatory mechanisms, of the Endangered Species Act from the model.

Response: The model was specifically designed to address biological aspects of the relationship between polar bears and their environment. Factor D addresses regulatory mechanisms and thus pertains to administrative or societal factors and therefore is outside the design scope of the model. In a broader sense, Factor D is implicitly built into the model structure because much of the existing polar bear data and knowledge were acquired under existing regulatory regimes. Therefore, although Factor D is not explicitly incorporated, the existence and function of the current regulatory environment is indirectly incorporated through the model parameterization.

Comment (99): The predicted extirpation in the Divergent and Seasonal Ecoregions does not follow from the results of the carrying capacity model or from Durner et al. (2007) which indicated that the carrying capacity would be reduced by 32-48 percent.

Response: The discrepancies between models relates to differences in model construction and complexity, and to differences in input variables and data incorporated into each model. The CM model is, by design, a simplistic model intended to illustrate future scenarios based solely on habitat availability expressed as annual mean extent throughout the Arctic. In contrast, the BM incorporates many other potential stressors. Similar to the CM, the added stressors were evaluated for the four ecoregions overlaying the Arctic. As a result, the models have different outcomes, although they show the same trend of decreasing numbers of polar bears and optimal habitat over time. The Durner et al. (2007) model describes how polar bear use sea ice, the conditions that are considered optimal habitat, and how future loss of sea ice habitat will influence optimal habitat within the Arctic Basin.

Comment (100): It is unclear why the control of human activities such as hunting would qualitatively increase the probability of persistence of polar bears in the Archipelago and Convergent Ecoregions but not the Divergent and Seasonal Ice Ecoregions.

Response: Both the Archipelago and Convergent ecoregions are forecasted to experience the effect of sea ice loss later in time and to a lesser degree of magnitude than the Divergent and Season Ice ecoregions. The primary reason for the difference is that in the Divergent and Seasonal ecoregions, the predicted changes in sea ice habitat are so great that they overshadow all other stressors in their potential effects on polar bears. It stands to reason that by mid-century, control of hunting and other human activities will have its most positive impact in those ecoregions where polar bears are predicted to persist the longest. As the authors illustrate in Figure 14, page 95 of the report, the control of human activities contributes a relatively small positive influence on the modeling outcomes and did not qualitatively change the overall prediction of extinction.

Comment (101): The outcomes of the carrying capacity models demonstrate the persistence of polar bear populations across all four ecoregions, albeit at reduced abundance in three of the regions. An observation noted that 5 of 10 GCMs predict ice coverage higher or about the same as in 2007. The commenter suggested that a better approach would be to project the carrying capacity model over a 10-20 year period.

Response: The USGS selected 10 GCMs for their analyses based on the concordance between their simulations of summer sea ice extent from 1953-1995, and the observational record of sea ice extent for the same period. The record setting minimum ice record for September 2007 suggests that existing GCMs may be conservative in their projected sea ice extents. The USGS forecasted the status of optimal polar bear habitat in the polar basin and the status of polar bear populations range-wide by four ecoregions at selected time steps throughout this century, including mid-century. Mid-century conforms to the foreseeable future as defined by the Service in its proposal to list polar bears as threatened under the ESA. As noted earlier in the response to comment 64, using GCMs to develop forecasts for specific decade by decade comparisons implies a greater level of temporal precision in the GCMs than exists.

Comment (102): It would be more appropriate to drop the use of GCMs in favor of a time series model in order that forecasts were entirely empirically based with variance that would completely capture the uncertainty in the projection. Several recommended steps that included the development completely different modeling approach and inputs were suggested.

Response: Use of a time series model would likely result in a more dramatic decline than that forecast by the BM, because the current rate of sea ice decline is greater than the rate of decline forecasted by GCMs. Also, time series models project forward based on the assumption that the system will behave in the future as it has in the past. Time series models cannot anticipate fundamental system change. GCMs do have the ability to allow fundamental and non-linear changes in the behavior of the system that could result because of different thresholds being reached (e.g., critical level of ice thinning). However, we also recognize that there may be other useful potential approaches to modeling this system that are identified in the future and some variation of the time series model may hold promise. For now the techniques that have been selected enjoy a consensus of support among the modeling community and they provided useful insights into the foreseeable future. All models used describe and appropriately document uncertainties and the influence of uncertainty on outcomes, and thus provide information useful in our overall analyses.

Comment (103): The BM modeling outcomes should not be used to corroborate the results of the deterministic modeling effort since it did not include critical observational information from Inuit.

Response: The BM model was not used to corroborate other model results nor was the carrying capacity used to validate or corroborate the BM. Each model was developed and run independently and provides different and independent views and outcomes.