United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Office of the Director
Reston, Virginia 20192

In Reply Refer To:
Mail Stop 104
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MEMORANDUM

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To: Director, Fish and Wildlife Service
Solicitor

From: Mark D. Myers
Director, U.S. Geological Survey

Subject: The Challenges of Linking Carbon Emissions, Atmospheric Greenhouse Gas Concentrations, Global Warming, and Consequential Impacts

In response to a request from Dale Hall, Director, U.S. Fish and Wildlife Service, the U.S. Geological Survey has summarized some of the latest climate results from the science community in defining CO_2 loading from individual actions and specific biological responses. These results indicate that current science and models cannot link individual actions that contribute to atmospheric carbon levels to specific responses of species, including polar bears.

Output of Human-induced CO_2 from numerous sources is leading to greater concentrations of CO_2 and other greenhouse gases (GHG) in the Earth's atmosphere. The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Synthesis Report states:

Global GHG emissions due to human activities have grown since pre-industrial times, with an increase of 70% between 1970 and 2004.

Global Atmospheric concentrations of CO_2, methane, and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years.

Most of the observed increase in global average temperatures since the mid 20th century is very likely due to the observed increase in anthropogenic GHG concentrations. It is likely that there has been significant anthropogenic warming over the past 50 years averaged over each continent (except Antarctica).

Consequently,

Warming of the climate system is unequivocal, as is now evidenced from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level.

Past and current models regarding climate change and its subsequent impacts (including global warming-related sea ice loss) have primarily been developed at global to continental scales. GHG emissions, while occurring at point sources, are considered in these climate modeling studies to be representative of continental to global atmospheric composition.

The Climate Change Science Program's (CCSP) Synthesis and Assessment Product (SAP) 1.1, *Temperature Trends in the Lower Atmosphere,* states:

In an ideal world, there would be reliable quantitative estimates of all climate forcings- both natural and human induced- that have made significant contributions to surface and tropospheric temperature changes. We would have detailed knowledge of how these forcings had changed over space and time. Finally, we would have used standard sets of forcings to perform climate change experiments with a whole suite of numerical models thus isolating uncertainties arising from structural differences in the models themselves. Unfortunately, this ideal situation does not exist.

In regard to the linkage between climate change related warming and associated impacts, the IPCC Fourth Assessment states:

Difficulties remain in simulating and attributing observed temperature changes at smaller than continental scales.

The final conclusion that can be reached from this information is that human-induced global warming can be observed and verified at global to continental scales where cumulative GHG concentrations can be measured and modeled. Climate impacts, however, are observed at specific locations, at much more specific and localized scales--incongruent with the global scale of the aforementioned measured and modeled climate forces. It is currently beyond the scope of existing science to identify a specific source of CO_2 emissions and designate it as the cause of specific climate impacts at an exact location. This point is emphasized in the CCSP's SAP 1.1, *Temperature Trends in the Lower Atmosphere*:

The positive detection results obtained for GHG-only fingerprints were driven by model-data pattern similarities at very large spatial scales (e.g. at the scale of individual hemispheres, or land-vs.-ocean behavior). Fingerprint detection of GHG effects becomes more challenging at continental or sub-continental scales. It is at these smaller scales that spatially heterogeneous forcings, such as those arising from changes in aerosol loadings and land use patterns, may have large impacts on regional climate.