Younger sea ice and scarcer polar bears

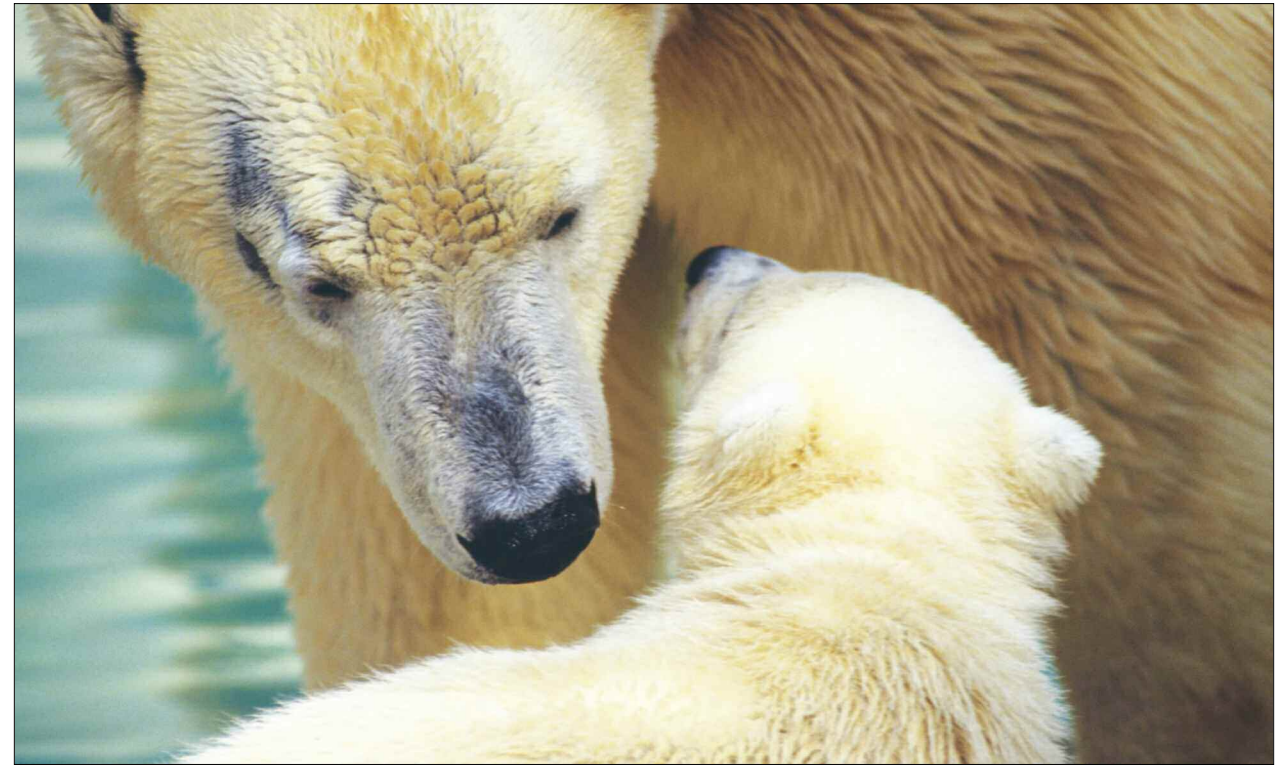
"The perennial ice is the mainstay of the Arctic ice cover."

Joey Comiso
NASA Goddard Space Flight Center

by Jane Beitler

In late summer of 2005, sea ice covering Arctic waters shrank to the lowest extent ever measured in nearly thirty years of satellite records. This record low was quickly shattered in 2007, and nearly again in 2008; yet these lows were only the exclamation points in decades of decline, a trend that scientists say is increasingly unlikely to slow or reverse. The changes that cascade from dwindling Arctic sea ice affect polar bears, whose lives are closely tied to seasonal ice cycles. George Durner, a research zoologist said, "Polar bears evolved to take advantage of an empty niche on the surface of the sea ice, which is key to their survival."

The 2005 record low spurred the United States Department of the Interior to ask for scientific projections of polar bear survival and population trends into the 21st century. The news was not good: if sea ice declines at the rate that scientific models predict, only one-third of the world's polar bears will survive by the end of the 21st century.



Arctic sea ice provides critical habitat for polar bears. Researchers are increasingly concerned that negative trends in summer sea ice extent may affect polar bear reproduction and species survival. (Courtesy Photos.com)

Durner, who helped develop the polar bear outlook, relies on data about sea ice changes from researchers like Joey Comiso, a sea ice specialist at NASA Goddard Space Flight Center. Comiso has studied sea ice using satellite data for years, but recently he began to focus on changes in perennial ice, the older, thicker ice that persists through the summer melt season. The data lead Comiso and Durner to think that both summer sea ice and bears may be at risk of vanishing much sooner than anyone thought.

The cycle of ice and bears

Durner, a longtime polar bear researcher at the United States Geological Survey (USGS) Alaska Science Center, knows what sea ice and its cycles mean to bears. He said, "In the eye of the polar bear, not all sea ice is equal. Bears seem to prefer sea ice that's relatively extensive, as a platform for hunting and for safety from ocean storms." Bears take refuge in the drifts next to pressure ridges of sea ice piled up by wind and ocean currents. From autumn until spring, bears in the Beaufort Sea find the best sea ice conditions in the area between shore-fast sea ice and the active sea ice pack.

In summer, sea ice melts first along the heat-absorbing Alaskan coastline. Durner said, "Polar bears find cracks in the ice pack that are narrowly open or thinly frozen over, for hunting seals." Most bears in the Beaufort and Chukchi Seas stay on the main pack to hunt, as it recedes miles from shore. Durner said, "Bears distribute themselves along the ice edges, where they have better access to seals." Outside of the main ice pack, isolated ice floes break into smaller floes or large patches of unconsolidated ice. Bears that are isolated from the main pack or land use these floes like a series of floating islands for hunting or resting. Eventually the floes become too small for a bear, which may have to swim to the main ice pack or to land.

In fall, ice and bears return nearer to shore. "As autumn progresses, temperatures cool, and ice begins to form again. Bears follow that leading edge of ice south, eventually occupying the shallow waters of the continental shelf, where the seal population is highest," Durner said. Then polar bears build fat stores necessary for winter survival, and pregnant females in particular fatten in early autumn to fuel their long winter fast and the nursing of their cubs. Later in autumn, they look for winter birthing dens near the coast or on stable ice pack, near good hunting habitat. Long swims between sea ice and shore deplete their body stores, affecting their reproductive success.

How fast and how much change?

The receding summer sea ice edge means bears are placed further from this productive seal habitat. Durner said, "Right now in September, the edge of the main pack in the Beaufort Sea is more than 400 miles north of Alaska. Many polar bears are in deep water areas where few seals are available, or bears are on melting floes surrounded by miles of open ocean. What does it mean for polar bears that have to summer for a long time in the deep water? How do they fare compared to bears that summer on land, and what are the energetic costs to bears forced to swim long distances?"

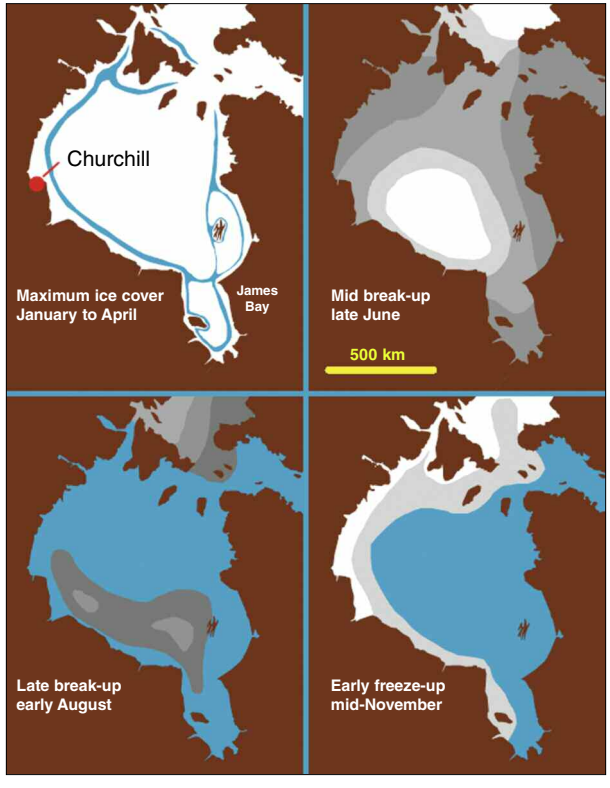
For pregnant females in the southern Beaufort Sea, the receding ice edge has lengthened their travel between ice pack and dens by six to eight kilometers (four to five miles) each year since 1979. As sea ice recedes even faster, by 2060 the distance may reach 1,500 kilometers (932 miles), increasing the time for bears to reach their dens by nearly a month. Durner and colleagues looked at relationships between sea ice conditions, polar bear body condition, and population patterns. For future sea ice projections, they turned to scientific climate models.

The climate models used several data sources, including sea ice trends from the satellite record. For years, Comiso and other sea ice researchers had watched summer's low mark sink lower, in a slow but steady trend. Data from three satellite sensors provide year-to-year comparisons of sea ice conditions: the Scanning Multichannel Microwave Radiometer (SMMR), the Special Sensor Microwave/Imager (SSM/I), and the Advanced Microwave Scanning Radiometer for Earth Observing System (AMSR-E), all archived at the National Snow and Ice Data Center Distributed Active Archive Center (NSIDC DAAC). From 1978 to 2007, the annual sea ice cover declined by 3 to 4 percent each decade; but after 1996, the decline accelerated. "All of a sudden, the decline changed to 10 percent per decade," Comiso said. Researchers knew that the loss of sea ice, which insulates the ocean and reflects solar radiation, would create conditions that allow it to melt even faster.

The models used this increased rate of decline for their ice projections, which the researchers in turn used in their polar bear studies. But as they completed their studies in 2007, the polar bear researchers heard news that added even more gloom to the population projections. Sea ice researchers reported that Arctic ice was declining even faster than the models had estimated. If sea ice was declining faster, it might accelerate the decline of polar bear populations even more. What was speeding up the decline of sea ice? Comiso thought that one of the factors the models were not accounting for was the increasing loss of older, thicker sea ice.

Younger and thinner

As summer turns into fall, the Arctic begins to cool. During the onset of the long dark winter, virtually all of the Arctic Ocean refreezes, but Comiso knew it was not that simple. He said, "I started looking at other types of ice that people normally ignore. The old ice that was normally able to survive summer months, year in and year out, is disappearing." This perennial ice was declining by 12 percent per decade.



Sea ice is a key habitat for polar bears. These four diagrams show the seasonal patterns of sea ice concentration in Hudson Bay, on the northern Canadian coast. White areas contain nearly solid sea ice; grays indicate lower concentrations of ice; blue indicates open water. (Courtesy G. Durner)

Comiso examined the perennial ice, which has survived two to seven summer melts. "The perennial ice is the mainstay of the Arctic ice cover. It's the base from which the seasonal ice builds up during the end of summer," Comiso said. As it ages, it becomes thicker, two to four meters (seven to thirteen feet) on average. When fall and winter set in, even more ice builds up on this surviving ice layer.

The thick ice is better able to endure through summer than the thinner ice. But because so much ice has melted in recent summers, Arctic sea ice now consists increasingly of thinner, first-year ice, averaging around a meter (three feet) thick. On average, perennial ice appears to be getting younger, and therefore thinner. "If you have a thinner ice cover, then it is more vulnerable to totally melting during the summer," Comiso said. Sea ice models lacked data on trends in older ice.

To help distinguish ice age in satellite data, researchers started with knowledge about older ice handed down from native Arctic people. For ages, Inuit have used older ice as a source of drinking water: they knew that after a few years, sea ice loses its saltiness. Freezing, thawing, and refreezing over several years causes salty brine to drain out of sea ice. So scientists found that ice that has survived at least one melt season had unique characteristics that made it transparent to radiation. Air pockets and other inconsistencies within this ice also scatter much of the radiation before it reaches the satellite sensor. Comiso used this information to classify the ice by age, which gave him information about variability and trends in the age of the ice cover. Now he could better understand the rapid decline in perennial ice.

Comiso refined the algorithms for obtaining ice age, using AMSR-E data as the baseline, since it has higher resolution and a wider swath than the other sensors. He was able to look closely at the long time series of sea ice growth and melt, resolving ice classes by analyzing and comparing data from the instrument's multiple frequencies. AMSR-E also provides more data around the geographic North Pole, which is typically covered by perennial sea ice.

The AMSR-E data, together with the historical SMMR and SSM/I data, helped Comiso confirm the faster retreat of the old ice. Although all types of ice are declining, including both seasonal ice and ice that is two or more years old, the oldest ice was declining the fastest. He said, "Compared to total ice extent and perennial ice extent, the trend for sea ice that is at least three years old is even steeper. This ice type is declining by 14 percent per decade."

The balance of the ice

Comiso thinks that the accelerating loss of older ice suggests that the perennial ice pack will eventually disappear. The function of perennial ice in the Arctic can be compared to a thick block of ice in a picnic cooler, which will stay frozen longer than small ice cubes that have many exposed surfaces. In a similar way, the greater mass of thicker, older sea ice resists melting. Starting each summer with an increasingly thinner, first-year ice cover, the Arctic Ocean could be ice free in summer much sooner than anyone ever thought possible.

Without summer sea ice for hunting, polar bears will struggle to survive, if they do at all. For now, despite the challenges, bear populations are holding up in some areas. Durner said, "We haven't measured a decline in the Beaufort Sea population, as researchers have observed in

western Hudson Bay in Canada. But in the Beaufort Sea, we see a relationship between poorer body condition and low sea ice years, and lower survival following a year of reduced sea ice. These are the same conditions researchers observed just before the Western Hudson Bay population declined."

Durner will go out on the ice next summer to see firsthand how the bears are faring. Then before the long, dark Arctic winter, he will return to land and use satellite data for a closer look at the cycle of sea ice in each bear habitat area. He said, "Having consistent passive microwave data since the 1970s has been so critical to our research over the past several years. If we didn't have that data available, I don't know where we would be."

To access this article online, please visit http://nasadaacs.eos.nasa.gov/articles/2008/2008_seaice.html.

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About the remote sensing data used

Satellite	NASA Aqua	Nimbus-7, Defense Meteorological Satellite Program (DMSP)
Sensor	Advanced Microwave Scanning Radiometer for Earth Observing System (AMSR-E)	Scanning Multichannel Microwave Radiometer (SMMR), Special Sensor Microwave/Imager (SSM/I)
Data sets used	AMSR-E/Aqua Daily L3 12.5 km Brightness Temperature, Sea Ice Concentration, & Snow Depth Polar Grids	Bootstrap Sea Ice Concentration from Nimbus-7 SMMR and DMSP SSM/I
Resolution	12.5 kilometer	25 kilometer
Parameters	Brightness temperatures, sea ice concentration, snow cover over sea ice	Brightness temperatures, ice extent, sea ice concentration
Data center	NASA National Snow and Ice Data Center DAAC	NASA National Snow and Ice Data Center DAAC

About the scientists

Josefino "Joey" Comiso is a senior research scientist in the Cryospheric Sciences Branch at NASA Goddard Space Flight Center. His research interests include climate change studies in the polar regions as inferred from historical satellite data with emphasis on passive microwave and infrared techniques. He has developed numerous algorithms and data sets related to sea ice extent, concentration, surface temperature, albedo, and clouds, and analyzed sea ice data for trends. NASA supported his research.

George Durner is a research zoologist at the United States Geological Survey (USGS) Alaska Science Center. He specializes in studies of spatial patterns of polar bears relative to reproductive status, habitat, and prey distribution, including mapping polar bear dens and using remote sensing to locate dens. The USGS supported his research. (Photograph courtesy G. Durner)

For more information

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Polar Bear Research at the Alaska Science Center
http://alaska.usgs.gov/science/biology/polar_bears