Whither Arctic Ice? Less of It, for Sure

Just a few years ago, the Arctic Ocean seemed to be skating on dangerously thin ice. In 1998, scientists working nearly 500 kilometers north of the Alaskan coast found the meters-thick sea ice there to be melting, thinning, and breaking up when it's usually rock solid. The next year, stunning submarine data revealed that Arctic sea ice had thinned by almost half since the 1950s.

With greenhouse warming declared official by a panel of experts early in 2001, the prospect of an ice-free Arctic looked all too real. But in the last couple of years, nature has hinted that the torrid pace seen in the 1990s will not be sustained. Computer models of the ice's fate under a growing greenhouse now concur that it will continue to shrink markedly, but it won't likely disappear in this century. The shrinkage should, however, be enough to open the Northwest Passage in summer and play havoc with Arctic life (see main text). All the scientific uncertainties aside, notes John Falkingham of the Canadian Ice Service in Ottawa, "the predominant scientific opinion is that there will be much less ice in the Arctic in future than we have seen in the past."

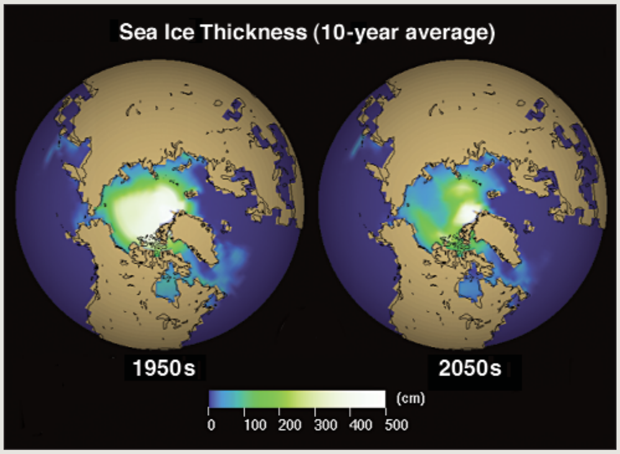
Only lately has Arctic ice come under close scrutiny. Never the stuff of deep-keeled, far-ranging icebergs, it mostly lay unwatched within the Arctic Ocean's bounds: the northernmost fringes of Russia, Alaska, the Canadian Archipelago, Greenland, and Scandinavia. Sailors' stories suggest that the far reaches of the North Atlantic were "an icier place in the first half of the 19th century," says polar researcher John Walsh of the University of Illinois, Urbana-Champaign. That was the tail end of the Little Ice Age, from which the world had emerged by the early 20th century. The trend that followed was frustratingly anecdotal and ill defined until a few years ago, when satellite monitoring revealed a 5% decrease in the extent of the ice between 1978 and 1998 (*Science*, 3 December 1999, p. 1828). That loss hardly represents a threat to the existence of Arctic ice in this century. But the thickness, gauged by nuclear submarine sonar, decreased 43% from the late 1950s to the mid-1990s. At that rate of decline, Walsh observed in 1999, the ice would disappear in a few decades. "It looked like [the ice loss] could be a harbinger of global warming," says physical oceanographer Humfrey Melling of the Institute of Ocean Sciences (IOS) in Sidney, British Columbia.

From the vantage point of 2002, the demise of Arctic ice looks less imminent: It has bounced back, or at least much of the way back, since 1998. "Every 10 years or so, for reasons we don't understand, there's a dramatic loss of ocean ice" over the top of North America, says Melling. Deciphering a long-term trend against a background of natural ups and downs in ice volume is tricky, he notes, especially when the reliable record goes back only a few decades. What would help, he and others agree, is a better understanding of what drives the variability of Arctic ice.

Recent computer models point to changing atmospheric circulation as the culprit in the abrupt ice thinning in the 1990s. "If we take into account everything we know about the Arctic," says physical oceanographer Gregory Holloway of IOS, "we see the ice readily moves sideways, piles up in some places, and thins in others" under the influence of shifting winds.

When the wind data of the past 20 years are put in a model that includes Arctic ice, the ice indeed thins over much of the Arctic in the 1990s. Coincidentally, it thins especially where the ice-monitoring submarines happened to have passed and thickens elsewhere or is blown right out of the Arctic Ocean. In light of such results from a number of modeling groups, the 43% decrease in ice thickness is an overestimate, says Holloway: "The real number is in the 10% to 15% range."

But if wind shifts were behind most of the thinning, what caused the wind shifts? For that, researchers look to the Arctic Oscillation, or AO (*Science*, 9 April 1999, p. 241). The AO is an erratic seesaw of atmospheric pressure that alternately raises pressure over the North Pole and then in a ring passing over southern Alaska and central Europe. The pressure shifts drive circulation changes, boosting westerly winds swirling around the pole when the AO kicks into its so-called positive phase. That's just what happened starting in 1989 as the AO pumped up winds in the vortex ringing the pole and swept unusual warmth over high latitudes. The ice responded, culminating in the lean ice year of 1998. Since then, "it looks like things are shifting back again," says Melling. The AO has backed off from its extreme positive phase, and the ice has been coming back, although both the AO and the ice volume remain far from their long-term averages.



On thin ice. Current models suggest that the Arctic Ocean's sea ice could lose more than half of its 1955 volume by midcentury.

So the AO could be driving variations in Arctic ice, but what drives the AO? Just about everything, it seems. It's a natural mode of the atmosphere, just as a drum has a natural mode of vibration. Hit a drum almost anywhere with almost anything, and much the same sound comes out; hit the atmosphere—with random jostlings, sunlight-reflecting volcanic ash in the stratosphere, variations in solar brightness, or added greenhouse gases—and it will oscillate with the pattern of the AO. An oscillation's duration can vary depending on what is doing the hitting, however. A random, natural swing in the AO lasting a decade might account for the ice loss of the '90s, and scientists are increasingly suspicious that the slowly building greenhouse is driving the observed decades-long swing toward the positive AO phase on which decadal swings are superimposed.

Researchers are using their climate models to take the AO, warming, and ocean circulation changes into account and divine the future of Arctic ice in the coming greenhouse. "You can come up with a wide range [of outcomes]," says Walsh, who's chairing a chapter on ice for a report due out next year as part of the Arctic Climate Impact Assessment. One model wipes out all Arctic ice in summer by 2050, but three out of the five models only open summertime passages in the second half of the century, retaining some ice year-round in 2100.

Even in an ice-diminished Arctic, winter will remain frozen solid. But thanks to global warming, summers will likely see more frequent early springtime meltback of the ice from the shore and farther retreat toward the pole, Walsh says. And that will gradually expose new frontiers—and new perils—for those who venture there.

–R.A.K.

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