ECOLOGY

Arctic Life, On Thin Ice

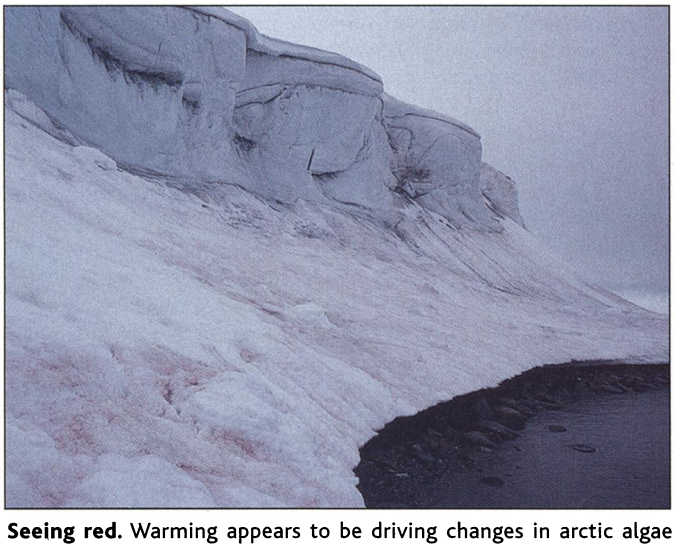
Field observations from the Beaufort Sea to Hudson Bay suggest that many species are floundering in a warming environment

Ivory gulls are disappearing—or so say Inuit hunters living on the northernmost fringes of Canada. No one is sure that the hunters' claim is true; ivory gulls lead mysterious lives, cloistered in remote aeries far from prying eyes. Besides, scientists are loath to rely on anecdote. But biologist Grant Gilchrist of the Canadian Wildlife Service (CWS) takes the observation seriously. The Inuit, he notes, "live on ice," like the gulls that forage the frozen Arctic all the way to the North Pole. And he believes in statistics, too: Arctic ice cover is melting, transforming the ivory gull's habitat.

Sea ice in the Arctic now covers 15% less area than it did in 1978; it has thinned to an average of 1.8 meters, compared to 3.1 meters in the 1950s (*Science*, 3 December 1999, p. 1828). If this trend continues, in 50 years the sea ice could disappear entirely during summers—possibly wiping out ice algae and most other organisms farther up the food chain, including polar bears. Whether or not that Arctic nightmare comes true, temperature fluctuations and winds driving the melting are already making many cold-weather creatures uncomfortably warm. And melting is bringing a new threat: people and their machines. In 1999, Russian companies sent two huge dry docks to the Bahamas through the usually unnavigable Northwest Passage, which winds through the labyrinthine Canadian Arctic Archipelago above the North American mainland. The route is also being eyed by oil companies drilling off northern Alaska.

Even when compared to the Antarctic, the Arctic Ocean was long thought a biological desert: hemmed in by land, it is choked with ice nearly year-round. But studies have found that it can be a rich, dynamic habitat. The ice partially breaks up during the brief summer, forming a moving jigsaw puzzle of floes driven by wind. This creates openings for life: Amid the intricate topography, diatoms and invertebrates dwell within the ice or in narrow open-water leads between floes. Algae such as *Melosira arctica* form slime jungles on the ice's fleecy underbelly, and clouds of zooplankton below graze on the algae or each other. In the 1970s, Igor Melnikov, a biologist with Moscow's P. P. Shirshov Institute of Oceanology, studied the Beaufort Sea in the Arctic Ocean's lower reaches and found 200 species in various niches—up to 140,000 individuals per cubic meter in the ice.

Now with the ice thinning, there is evidence that this food web is ailing. In winter 1997–98, Melnikov returned to his original study area during the international climate-change project SHEBA ("Surface Heat Budget of the Arctic Ocean"). Melnikov found everything changed. The diatoms were gone, replaced by a few common freshwater algae. Melnikov says the algae may have taken over because melting has formed a 30-meter-thick layer of relatively fresh water below the remaining ice, a third deeper than it was 20 years ago. Ice-related invertebrates had largely disappeared, including the most abundant—his own *Theristus melnikovi*. "It is a type of catastrophe," he says. His findings, in press at *Deep Sea Research*, were not a one-season phenomenon: He duplicated them last summer aboard a Russian icebreaker.



Seeing red. Warming appears to be driving changes in arctic algae populations as melting adds fresh water below the ice.

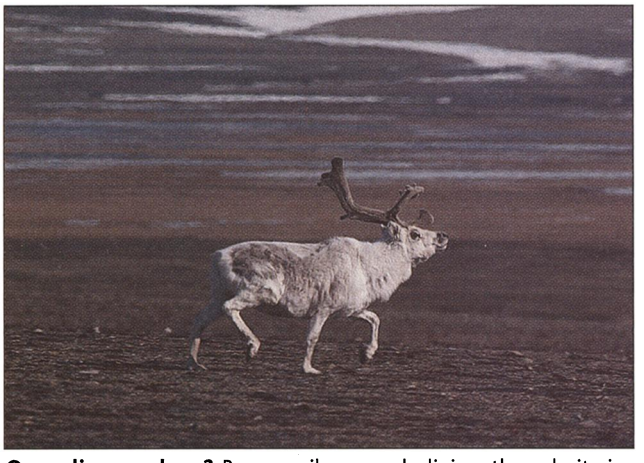
CREDIT: FRANCOIS GOHIER/PHOTO RESEARCHERS

There is no evidence of such shifts farther north—yet. However, says Rolf Gradinger of the Institute of Polar Ecology at Christian-Albrechts University in Kiel, Germany, who studies sea ice closer to the pole, "these are big changes, and we are worried about the food web if they spread."

Because smaller ice creatures are food for larger ones, experts fear a domino effect. For one, tiny carcasses rain down on the Arctic sea floor, nourishing bottom dwellers such as clams—the main prey of walruses. Ubiquitous arctic cod operate like upside-down vacuum cleaners on the ice's undersurface, sweeping up whatever they can get with their upturned mouths. Cod are the primary prey of many kinds of seabirds, whales, and seals. At the top of the food chain are the polar bears, dining mainly on seals.

Besides fraying the food web, the ice pack's shrinkage threatens the livelihoods of the big animals, which hunt, rest, and reproduce on the pack. Some melting and fracturing is necessary for seabirds to dive for fish, for most seals to haul themselves out, and for whales to surface for air. But extensive melting puts prey out of reach for some species. At the height of summer, the ice breaks up along the pack's southern fringes, triggering a burst of plankton productivity along the edges. The breakup also exposes countless cod, schooled so thickly they turn the water black. Ed Carmack, an oceanographer with the Canadian Department of Fisheries and Oceans, has witnessed thousands of harp seals, whales, and birds attracted to such areas for feeding frenzies. Whales and seals have no problem chasing the movable feast as the ice edge recedes earlier in summer and farther northward. But seabirds tied to cliffside nest colonies can forage only as far north as there is suitable land.

The plight of one bird species shows just how fine the balance between ice and open water must be for survival. At first, receding ice was good for black guillemots off Alaska's northern coast. Before the 1970s, summer cold and snow prevented them from nesting on Cooper Island, in the Beaufort Sea near Point Barrow, Alaska, says George Divoky of the University of Alaska, Fairbanks. As the seasonal ice edge pushed north, the birds settled and flourished, with numbers peaking at 450 in 1989; but in the last decade, the population has dwindled to 250. "The ice edge outran them," says Divoky. "Now it's way



On a slippery slope? Peary caribou are declining; the culprits include arctic warming and overhunting.

out in the Chuckchi-Beaufort Sea, where there is no land."

Some 3500 kilometers southeast of Barrow, along northern Hudson Bay, thick-billed murres are adapting to the receding ice edge by eating open-water fish such as capelin, says CWS ornithologist Tony Gaston. But capelin are less nutritious than cod, and Gaston has documented a decline in murre weight. The birds are also suffering a devilish twist: Populations of mosquitoes, never before a big problem in this area, have exploded in the higher temperatures. Bitten repeatedly on their big webbed feet, many murres, unable to flee while incubating eggs, keel over dead in their nests. "It's probably a combination of heat exhaustion and getting sucked dry by bugs," says Gaston, who will add fresh details to this tale in an article later this year in the journal *Ibis*.

No one is quite sure how the elusive ivory gulls, which dwell farther north, are faring. Some major colonies were discovered only in the 1980s on remote nunataks, mountaintops poking from vast glacial ice fields on high-arctic Ellesmere Island. These aeries may protect the birds and their young from bears and foxes unwilling to cross the barren inland glacial ice. Thus, if the glacial ice begins melting in concert with the sea ice, the birds could face a double whammy: loss of food and increased predation. Gilchrist hopes to find funding to study the nunatak aeries this summer.

Ringed seals, the most common northern seals, may have trouble adapting too, says Brendan Kelly of the University of Alaska's School of Fisheries and Ocean Sciences in Juneau. Ranging year-round as far as the pole, they never leave the ice pack, keeping breathing holes open all winter and making lairs under snow mounds. In spring, the snow lairs camouflage their new pups from polar bears and protect them from cold air. But in the current issue of the journal *Arctic*, biologist Lois Harwood of the Canadian Department of Fisheries and Oceans says the ice in the western Arctic broke up 3 weeks earlier than usual in 1998, and hungry pups were dropped into the water before weaning. Adults appeared thin, even though early breakup led to more available prey. "They were starving in the midst of plenty," says Harwood.

Kelly fears that the seals may already be in danger farther north even without visible ice melt. Monitoring of seals fitted with radio collars suggests that pups emerge from the protective snow lairs each spring precisely when warming saturates the snow with water, causing the mounds to collapse. Kelly believes that the earliest time at which pups can survive in open air is finely tuned to this saturation date. If this date is indeed shifting earlier, he says, "things may go very badly for them."

Things are already going badly for Peary caribou, but it's unclear why. The animals graze on high-arctic-island plants and lichens, but need ice to island-hop. One population normally migrates from Victoria Island to mainland Canada in the fall, but some are falling through the increasingly unstable ice. "If you fly over, you sometimes see a caribou trail heading across, then a little wormhole at the end, with a bunch of antlers sticking out," says Anne Gunn, a wildlife biologist for the government of Canada's Northwest Territories. On some islands, other populations have virtually disappeared, although it is uncertain whether the problem is too little ice, too many Inuit hunters or—as a side effect of changing weather—unusual freezing rains that ice over forage, making it inaccessible for grazing.

Even the mighty polar bears are suffering. In higher latitudes they spend almost all year hunting seals on the ice, although in lower ranges such as Hudson Bay, they retreat to land in summer, when waters open up. With warmer springs in the last 30 years, western Hudson Bay's waters have begun opening weeks early, forcing the bears to make for land around mid-July—a crucial time when they normally gorge on seal pups and store fat for the year. In a 1999 paper in *Arctic*, CWS biologist Ian Stirling recounts how early landfalls have caused the region's polar bears to suffer 15% declines in both average weight and number of cubs born between 1981 and 1998. While awaiting freeze-up, the bears have taken to hanging around the bayside town of Churchill, with its enticing garbage dump and hordes of bear-loving tourists. Predictably, wildlife officials have had to shoot some problem animals. Churchill now has a 23-cell "bear jail" for troublemakers—bigger than its people jail. Bears are held there until there's enough ice to airlift them out onto the bay.

Not all change is bad. "Further north, wildlife may be increasing," as solid ice opens up, says Stirling. Harp seals are being spotted in places where they hadn't been seen before, for example.

Although no one can say what the various observations mean for the ecosystem's long-term health, some answers may lie on the horizon. Starting in 2002, the National Science Foundation and the Office of Naval Research will fund a $17.5 million program to investigate the biology of climate change in the western Arctic. And the topic is getting a serious airing in the scientific community, including in symposia later this month at the Fingerprints for Climate Change conference in Ascona, Switzerland. "The 'meltdown' of the Arctic could be exaggerated, like the death of Mark Twain," says Carmack. "But that doesn't mean we should ignore it. We don't know how animals might adapt, or not. That's why we should be so concerned."

I was only hungry. Canadian polar bears are losing weight, having fewer cubs, and increasingly frequenting garbage dumps.

–KEVIN KRAJICK

Kevin Krajick is a writer in New York City.

CREDITS: (TOP TO BOTTOM) S. KRASEMANN/PHOTO RESEARCHERS; MANITOBA DEPARTMENT OF NATURAL RESOURCES