GLOBAL CHANGE

A Slowing Cog in the North Atlantic Ocean's Climate Machine

Oceanographers, who have begun to watch the slow churnings of the ocean much the way meteorologists observe the daily weather in the atmosphere, believe they have seen a new shift in ocean "climate." The giant vortex of an ocean current, or gyre, tucked into the northwestern North Atlantic appears to have slowed.

The weakening of this subpolar gyre in the 1990s may have been just a random fluctuation in one part of the complex of ocean currents that carries warm waters into the high North Atlantic. If so, this single cog in the Atlantic "conveyor belt" of north-south currents could soon recover.

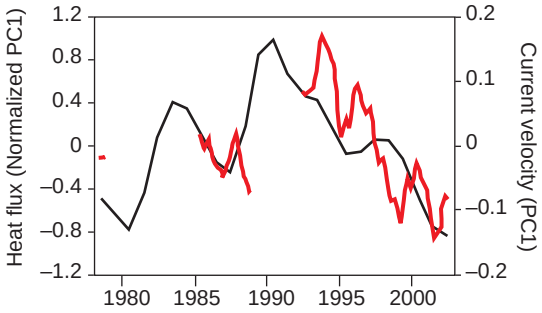
Or the subpolar gyre might continue to slow through this century as the whole conveyor belt brakes under the arresting hand of global warming. That would be no climate catastrophe—notwithstanding next month's climate disaster movie *The Day After Tomorrow*, which depicts chilling consequences of a breakdown of the conveyor. But the effects could be real enough, including a cooling of northern Europe, fewer Atlantic hurricanes, and more drought in the Sahel of Africa. The record of subpolar gyre behavior is decades shy of revealing what may be in store, but "there may well be a consequence" for the conveyor, says oceanographer Jochem Marotzke of the Max Planck Institute for Meteorology in Hamburg, Germany.

This latest hint of global change comes from what might be described as an ocean weather satellite. To take a snapshot of atmospheric weather, meteorologists measure atmospheric pressure so they can map out the centers of high and low pressure around which the winds blow. In the ocean, the highs and lows around which currents circle to form gyres are palpably manifest in the height of the sea surface at their centers. In a 15 April online report in *Science* (www.sciencemag.org/cgi/content/abstract/1094917), oceanographers Sirpa Häkkinen of NASA's Goddard Space Flight Center in Greenbelt, Maryland, and Peter Rhines of the University of Washington, Seattle, give satellite measurements of sea surface height over the far northern North Atlantic. The measurements were made by the U.S.-French TOPEX/Poseidon radar-altimeter satellite.

During the decade of observations between 1992 and 2002, the interior of the subpolar gyre, which is most intense between Labrador and Iceland just south of Greenland, rose by about 4 to 9 centimeters depending on location, Häkkinen and Rhines report. With a shallower and thus weaker low, the gyre should have slowed by more than 1 centimeter per second per decade, or about one-fifth of its flow. That's what seems to have happened: A set of current meters that was moored in the western edge of the gyre for 2 years in the mid-1990s recorded a slowing as the satellite altimetry showed a shallowing. "I think that is quite convincing," says Marotzke.

If the subpolar gyre continues to slow, oceanographers wonder what effect it could have on the conveyor belt, which they variously term the thermohaline circulation or the meridional overturning circulation (MOC). The gyre and the Labrador Sea that it encompasses make up "the Grand Central Station of global circulation," says Rhines. "There's so much happening there." On the broadest scale, the MOC carries warm surface waters from the South Atlantic into the far northern North Atlantic. The most obvious warm-water route is the Gulf Stream, whose northernmost branch abuts the southern edge of the subpolar gyre. The MOC also sinks cold, saltier water that moves southward in currents at mid depths and along the ocean bottom. Some of that sinking occurs in the Labrador Sea.

The forces driving the subpolar gyre are varied. The wind has immediate as well as delayed effects; anything affecting the buoyancy of surface water—heating or cooling, and evaporation or the addition of fresh water—can influence the sinking of surface waters; and the effects of these forces elsewhere in the Atlantic can propagate into the gyre. In the case of the 1990s slowing, ▶



Spinning down. When the North Atlantic's subpolar gyre began losing less heat (black) in the mid-1990s, it slowed (red).

CREDITS: (TOP TO BOTTOM) TIM MCDOWELL; S. HÄKKINEN AND P. B. RHINES

ScienceScope

Sudden Oak Quarantine



In a bid to stop the spread of the pathogen that causes sudden oak death, the U.S. Department of Agriculture (USDA) last week slapped an emergency quarantine on all plant nurseries in California. But some states say the move isn't strict enough.

The quarantine order followed the discovery of the funguslike pathogen in a large southern California nursery that had shipped thousands of plants to destinations around the United States (*Science*, 26 March, p. 1959). An urgent, nationwide testing effort has since found the pathogen in seven other states.

Twelve California counties were already under quarantine. Now, all state nurseries must certify plants from 59 host species (including azaleas, above) as pathogen-free before export. USDA is still working out inspection details. The fastest test, done by PCR, is prone to false positives. A time-consuming culture test, which USDA considers definitive, is more subject to false negatives.

Some states, however, are unhappy that the USDA action overrules total bans on California imports that they have already imposed. USDA's quarantine isn't "sufficiently tough," says spokesperson Terence McElroy of the Florida Department of Agriculture, which has asked USDA to uphold its broader ban. USDA spokesperson Claude Knighten, however, says the agency won't "regulate everything. ... We're basing our decision on science." —ERIK STOKSTAD

Hutchinson's Mixed Win

The Fred Hutchinson Cancer Research Center in Seattle last week mostly won a legal battle over a failed 1980s clinical trial. The Hutch, as it is known, was peppered by lawsuits after *The Seattle Times* ran articles in 2001 alleging that its doctors misled patient volunteers about the risks of a bone marrow transfer experiment and failed to disclose that researchers owned shares in a support company (*Science*, 6 April 2001, p. 25). Eighty-three of 85 cancer patients in the experiment died of various causes.

A superior court in Seattle allowed claims from five families but dismissed fraud and conflict-of-interest allegations. Last week the jury rejected four of the five remaining claims. However, it awarded the family of David Yingling $1 million, concluding that the Hutch had contributed to his death in 1983. An attorney for the Hutch has suggested that it may soon settle 10 other threatened lawsuits. —ELIOT MARSHALL

Häkkinen and Rhines deduce that surface waters within the gyre lost less heat to the atmosphere in the 1990s, warming and expanding waters there and thus raising the sea surface and slowing the gyre.

Oceanographers can't say whether the subpolar gyre's heating-induced slowing will continue. "We don't claim to show there is an irreversible global warming effect" on the gyre, says Rhines. Researchers have only two snippets of record before the launch of TOPEX/Poseidon in 1992, so they have no way to tell whether they're seeing a long-term, greenhouse-induced slowing of the gyre or just random natural variations.

Even if the subpolar gyre were to continue to slow, there's no agreement that it would make much difference to the MOC or climate around the Atlantic. On page 400, ocean modelers Andrew Weaver of the University of Victoria, British Columbia, and Claude Hillaire-Marcel of the University of Quebec in Montreal argue from published modeling and paleoclimate records that global warming might in fact shut down the sinking of surface waters in the gyre's Labrador Sea, as happened in 1995. But that needn't slow the MOC as a whole, they say, and would have a minor climate effect downwind in Europe. That scenario is less dramatic than an inundated New York City freezing up one summer's night, as Hollywood has it in *The Day After Tomorrow*, but likely closer to the truth.

–RICHARD A. KERR

BEHAVIORAL ECOLOGY

Why Male Bowerbirds Decorate As Well As Dance

What do female satin bowerbirds want? It's a puzzle that the males of this species face every Australian spring, when the choosy ladies make their rounds, evaluating the males' efforts to impress through their elaborately decorated mating arenas, or bowers, and their dances and songs. Eventually, each female mates with one male—presumably one that she's judged to be the best. Researchers say that the dances and songs are the best indicators of a suitor's physical condition. So why do males apparently need a swanky bower as well as a spunky dance to attract mates?

In this week's issue of *Nature*, behavioral ecologist and graduate student Seth Coleman and his colleagues at the University of Maryland, College Park, show that the males are actually sending messages to two different audiences: young, inexperienced females and older, wiser ones. Although the females ultimately want the same thing—a genetically top mate—they can't be wooed in the same way, so the males have devised different methods to present their qualifications.

"People are just beginning to think about these kinds of mixed messages," says Michael Ryan, an evolutionary biologist at the University of Texas, Austin. "We often think animals are directing their displays only at one audience when, in fact, they may be sending multiple messages to multiple audiences." This study, notes behavioral ecologist Jack Bradbury of Cornell University, presents a "brilliant experimental way to evaluate [such] multicue decision-making."

Even to an uninitiated observer, there's no missing the advertisement of a male satin bowerbird display. Unlike the mottled green female, the males are colored a brilliant purple-blue, with blue eyes and strongly contrasting yellow beaks. They build that same color scheme into their physical displays, constructing U-shaped arenas of yellow straw on yellow straw mats, which they then decorate with as many blue objects as they can find, such as feathers, glass, and bits of plastic. When a female comes courting, she stands inside the bower and watches as the male struts, arches his wings, and screeches his love tunes.

Because she will raise their offspring alone, she needs to make a careful choice, says Coleman. "That's the only thing that the male contributes: his genes. So she needs to be a good judge." The dance and song are the best measure of male quality because although males can steal blue objects from one another's bowers, "another male can't steal this [behavioral] trait."

So why decorate a bower? To find out, Coleman outfitted about 90 wild males and females at Wallaby Creek, New South Wales, with colored plastic leg bands to identify each one. Males at 14 of the 28 bowers in the study were each then given 50 strands of blue plastic from an old tarp as well as 20 small blue plastic tiles. After the males arranged these items in their bowers, Coleman glued them in place to prevent the birds from stealing from one another. He then recorded their trysts on automatic video cameras to compare the mating success of males with enhanced bowers to those that had only their own treasures to show off.



Showing off the bling bling. A male bowerbird decorates for potential mates.

CREDIT: S. COLEMAN

From previous studies, the team knew that females have three stages of decision-making. A female first visits several bowers when the males are not present to study the decorations. If she's pleased, she returns when the males are home to listen to their songs and watch their dances. And if she's happy with one male's performance, she builds a nest and returns to mate with him. Younger females are handicapped in their evaluations, however, because a male's intense singing and dancing often frightens them away.

Coleman found that females of every age returned to the most heavily decorated bowers, showing that the bowers played some role in each female's choice. But older females watched the male's entire show and mated with the one that gave the most demanding performance, basing their final decision on the best indicator of physical quality. In contrast, younger 1- and 2-year-old females lost their hearts to males who'd been given the extra treasure—and weren't necessarily the best at song and dance.

The fear factor in young females may thus explain the male's determination to collect as many blue objects as possible. "That's the best way he has to communicate his fitness to these younger birds," says Coleman, noting that because blue items are rare in the natural environment, they can also be "good indicators" of the male's overall quality. For wooing young female bowerbirds, it seems, blue bling bling is just the thing. –VIRGINIA MORELL

Virginia Morell is a writer in Ashland, Oregon.