Coral's Chilling Tale

Ancient reefs may resolve an ice-age paradox

By RICHARD MONASTERSKY

Had the Empire State Building existed 18,000 years ago, a prehistoric tourist visiting Manhattan would have strolled right past it without even noticing. This was the end of the Pleistocene epoch, the peak of the last ice age, when the land that would become New York City lay hidden beneath a sheet of ice more than twice the height of the famous skyscraper.

Vast glacial sheets blanketed much of the northern United States, Canada, and Europe, covering more than 10 percent of the northern hemisphere. On the other side of the globe, the sea ice surrounding Antarctica expanded to nearly double its modern wintertime area.

With so much ice, the midlatitudes and polar regions shivered through this period, enduring temperatures substantially below those of today. But the tropics' tale is different and far more difficult for scientists to read. Depending on where they look, researchers find contradictory evidence about how the low latitudes fared during the ice age. Oceanographers who study deep-sea sediments detect signs that the tropical seas weathered the glacial epoch with remarkable stability, hardly cooling at all. Yet researchers working on the continents and islands record evidence of marked cooling there.

Far from just a historical riddle, the tropical paradox is important for those trying to forecast how conditions on Earth will change in the future. Before they can confidently predict the climate to come, researchers must hone their primary tool — sophisticated computer models — by trying to simulate past periods in Earth's history. Such tests, however, run into trouble with the evidence of tropical warmth during the last ice age. When researchers try to re-create the climate of this period, they cannot coax the tropical oceans to remain warm while the rest of the globe cools.

This discrepancy troubles climate researchers because it raises the possibility that their models lack a critical element that will hinder their ability to accurately predict future changes.

Modelers may now get help from an unexpected ally: ancient coral. At an American Geophysical Union meeting in December, paleoceanographer Thomas P. Guilderson reported that his study of coral reefs growing off Barbados shows that at least part of the tropical oceans may have cooled significantly during the last ice age, in keeping with what climate models predict.

Guilderson, from Columbia University's Lamont-Doherty Earth Observatory in Palisades, N.Y., focused his study on the coral species *Acropora palmata*, which grows close to the ocean surface. To extract information about past temperatures, Guilderson used two methods, one of which exploits a mistake the coral makes while building its calcium carbonate shell. Because strontium atoms in the ocean resemble calcium atoms, *A. palmata* occasionally incorporates strontium into its shell, a slipup that occurs more frequently in colder water.

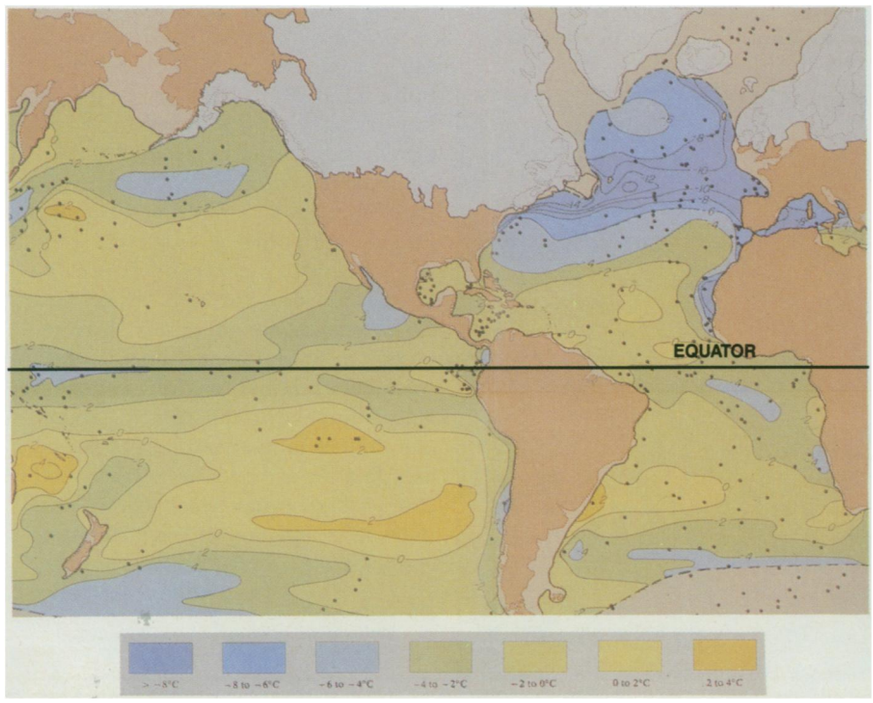
By measuring the ratio of strontium to calcium in the coral, Guilderson could gauge the temperature of the water at the time the animal lived. For the peak of the last ice age, he found that the coral's strontium-calcium ratio indicates that surface waters off Barbados were 5°C colder than they are today. Using another technique, Guilderson found evidence of a similar amount of cooling when he analyzed the ratio of oxygen isotopes in the coral. He describes these results in the Feb. 4 SCIENCE.

Although the two independent techniques agree on the tropical cooling, they contradict most other methods of judging past ocean conditions. These all propose that the low-latitude oceans remained within 1°C or 2°C of their current temperatures and even warmed in some places.

The strongest evidence for stable tropical temperatures comes from a major study completed in 1981 that analyzed the species of plankton found at different sites around the globe. Called the Climate Long-Range Investigation and Mapping Program (CLIMAP), this effort found that the mix of plankton species currently living in the tropics closely resembles the community during the last ice age, signaling that minimal temperature change occurred there during the glacial epoch. In contrast, the variety of species in the midlatitudes changed dramatically, indicating that the surface ocean during the ice age was 4°C to 12°C cooler during summer months than it is now.

Other evidence collected from the analysis of oxygen isotopes in plankton also suggests that the tropics remained close to today's temperatures.

If true, the tropics may be relatively insensitive to climate change and therefore may not react strongly to a warming in the future, says David H. Rind, a climate modeler at NASA's Goddard Institute for



CLIMAP/Geological Society of America

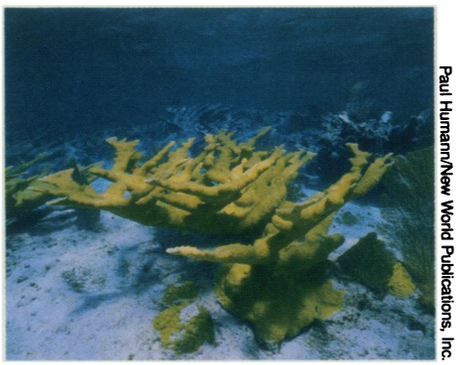
Steaming through the cold? Research in the 1970s indicated that the tropics stayed warm during the last ice age. In a map from that study, colors indicate ocean temperatures of 18,000 years ago relative to today's conditions.

Space Studies in New York City.

Since the early 1980s, geologists have recognized that the CLIMAP results do not square with evidence on land, which records dramatic changes in the tropics. During the height of the ice age, snow lines on mountains in New Guinea, Hawaii, and equatorial Africa lay some 1,000 meters lower than they do today, suggesting a cooler climate back then. Pollen preserved from that time reveals vegetation patterns that also indicate significantly lower temperatures in the tropics.

CLIMAP researchers in the past have stood by their results, arguing that the land data don't reveal much about ocean temperatures because they come from high-altitude sites and therefore may not reveal what happened closer to sea level. The new coral results, however, come from the ocean itself and directly contradict the older CLIMAP findings.

Oceanographers are now trying to figure out why corals and plankton tell such a different story about tropical temperatures. CLIMAP participant Warren L. Prell of Brown University in Providence, R.I., criticizes the coral study, saying that the Barbados reefs may record local changes rather than the more pervasive ocean-wide conditions revealed by CLIMAP. Besides, he finds it hard to accept significant ocean cooling in this region because the relative abundance of plankton species in the tropics did not change.



Paul Humann/New World Publications, Inc.

***Subsea historian:** The species* Acropora palmata, *better known as Elkhorn coral, records past ocean temperatures.*

"If you made a major change in the tropics, such as cooling by 5°C, one would expect the plankton to respond to that. It's a little like moving from Maine down to Florida. Would you see a difference?" Prell asks.

Guilderson defends his study, arguing that water from the open ocean bathes Barbados; thus corals growing off its shores store information about general conditions in the western equatorial Atlantic rather than just local variations.

On CLIMAP, Guilderson contends that the older study may have missed changes in the tropics because two of the dominant plankton species in the region can withstand big temperature changes and could have continued to inhabit the tropics even if the ocean cooled significantly.

Guilderson cautions that his results do not end the debate, because they apply only to the tropical western Atlantic and cannot reveal what happened elsewhere. He and his colleagues are currently studying corals from a site in the Pacific to flesh out the picture of ice-age changes across the tropics.

If such work reveals a general pattern of ice-age cooling, it would solve a problem that has plagued climate researchers for more than a decade, says Rind. It would also suggest that the tropics are more sensitive to climate change than the CLIMAP results indicate.

Researchers must resolve this question of sensitivity before they can anticipate how the tropics will react to the increasing concentrations of greenhouse gases in the atmosphere. If they are insulated from change, then countries in the low latitudes, mostly developing nations, may not suffer much from the anticipated global warming. However, if the tropics do warm along with the rest of the world, climate models indicate that the low latitudes could suffer extreme droughts as a result, Rind says.

For the answers they need, however, paleoceanographers must return to the lowly animals and plants of the sea, which harbor within their shells hints of the ice-age climate. □