Carbon dioxide buildup harms coral reefs

Reefs and carbon dioxide: Not a gas.

The accumulation of carbon dioxide gas in the atmosphere is stunting the growth of coral reefs and represents a significant new threat to reef health, reports an international team of researchers.

"We haven't really considered this before, and it appears that it is a potential problem," says biologist Joan A. Kleypas of the National Center for Atmospheric Research in Boulder, Colo.

Recent experiments conducted in French aquariums and in the Biosphere 2 facility in Arizona alerted Kleypas and her colleagues to the dangers of carbon dioxide. In these controlled situations, scientists found that adding extra carbon dioxide to water slowed the rate at which coral and reef-building algae secrete the mineral calcium carbonate—the skeleton of reefs.

"We have very limited information, but all the information is pointing in the same direction," says Jean-Pierre Gattuso of the National Center for Scientific Research in Villefranche-sur-mer, France, who conducted some of the experiments. Kleypas, Gattuso, and their colleagues calculate the potential effects of carbon dioxide on reefs in the April 2 SCIENCE.

The news will come as a surprise to many biologists because they have largely ignored how reef organisms respond to carbon dioxide changes, says coauthor Robert W. Buddemeier, a geochemist at the University of Kansas in Lawrence.

As carbon dioxide pollution accumulates in the atmosphere, it seeps into the upper ocean and reacts with water. These reactions increase the concentration of bicarbonate ions (HCO_3^-) and decrease the concentration of carbonate ions (CO_3^{2-}). Coral, clams, and many other organisms build their shells by bringing carbonate ions together with calcium to form three different calcium carbonates.

Coral and a group of organisms known as calcifying algae require a higher concentration of carbonate ion and hence are more vulnerable to the extra carbon dioxide than are clams, say the researchers.

Since the beginning of the Industrial Revolution, carbon dioxide amounts in the atmosphere have risen from 280 to 365 parts per million. This has caused a 6 to 11 percent decline in calcium carbonate formation by coral and calcifying algae, calculate the authors. This rate of growth, they project, will drop another 8 to 17 percent by the time carbon dioxide amounts double, expected midway through the next century.

The change will not kill coral, but it will slow its growth and weaken reefs. "The coral is likely to be more fragile, more susceptible to storm damage, erosion, and breakage," says Kleypas.

Stephen V. Smith of the University of Hawaii at Manoa says that "from the point of view of coral reef communities, this potentially is an extremely important consideration."

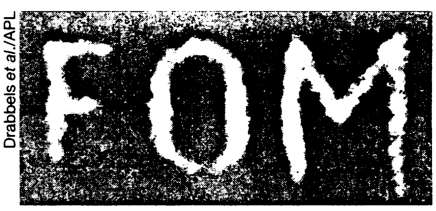
The experiments conducted thus far, however, have only examined a small number of species over short periods. Researchers need to test other species, he says, and also determine whether coral and calcifying algae eventually adapt to the extra carbon dioxide.

Coral reefs are already under siege from a vast assortment of threats, ranging from pollution to the recent problems of bleaching linked to excessive ocean temperatures (SN: 6/15/96, p. 379). The burden of additional carbon dioxide is adding another significant source of stress, says Kleypas.

Given all the problems, Buddemeier sees a bleak future for coral reefs: "A lot of the pretty reefs that people like to look at and fish in and that provide breakwaters are not going to be with us for a whole lot longer." —*R. Monastersky*

Cloud of bloated atoms takes hot shots

Drabbels *et al.*/APL



Infrared light passed through a stencil and ionized atoms to record these letters.

Using drifting, highly excited atoms as light-sensitive film, researchers have created a new type of camera for making images from infrared light.

Although the prototype device misses much of the light from its subject, its potential advantages over current technology include a faster shutter speed and the ability to be tuned to a particular wavelength. The camera also needs no cooling and works over an exceptionally large range of wavelengths—from 1 to 100 micrometers, its developers say.

"What we present here is a completely different approach" to infrared imaging, says Bart Noordam of the FOM Institute for Atomic and Molecular Physics in Amsterdam. He and his colleagues describe their camera in the March 29 APPLIED PHYSICS LETTERS.

Infrared pictures have proved useful in a wide range of applications, such as night vision, analysis of the composition of surfaces, and observations of celestial bodies enshrouded in dust that blocks visible light (SN: 3/13/99, p. 172). Infrared radiation, beginning just beyond the red end of the optical spectrum, has longer wavelengths and lower energy than visible light.

Because of their low energy, infrared photons pose a challenge for camera designers. Standard semiconductor detectors have limited sensitivity in the infrared because the photons have too little oomph to dislodge electrons and so create a telltale current. Moreover, all materials—including camera parts—at room temperature give off their own infrared radiation, usually making cooling necessary to suppress those emissions.

Noordam and Marcel Drabbels, also of FOM, have devised a way to use a cloud of atoms in an unusual state in order to detect infrared photons. A Rydberg atom is an atom having one highly excited electron orbiting far beyond the usual electron paths. Physicists have known about Rydberg atoms since the start of the century, but in the last 2 decades, lasers have made them easy to generate.

The Dutch team beamed an ultraviolet laser into clouds of potassium or cesium atoms, in each case creating a half-millimeter-thick sheet of Rydberg atoms. Because the far-flung electrons are weakly bound to the rest of the atom, low-energy photons from an infrared source can knock them loose. This creates electrically charged ions. An electric field accelerates the ions into an amplifier, which in turn excites a phosphor on a screen, creating an image of the infrared light.

By adjusting the ultraviolet laser and the electric field, the researchers can select which infrared wavelengths the Rydberg atoms most readily absorb. Having a tunable camera makes cooling unnecessary because background radiation can be screened out, Noordam says.

"It's a very clever idea," says Thomas F. Gallagher of the University of Virginia in Charlottesville. On the other hand, "it's not spectacularly efficient," he notes.

Indeed, the camera catches only 1 in 100 million infrared photons that pass through it. The inventors are working on a new version, with a thousand-fold greater efficiency, but the ultimate performance of the camera remains uncertain, they say. —*P. Weiss*