Sleeping with the fishes

Ocean acidification is the latest in a slew of threats to coral reefs. A team of scientists is now getting right up close to Florida's reefs to better understand how their inhabitants may be affected. **Mark Schrope** reports from the Aquarius Underwater Laboratory.

Chris Martens, a marine biogeochemist from the University of North Carolina, Chapel Hill, is seated at a table some 15 metres below the sea surface in the world's only functioning underwater laboratory. Outside a large porthole next to him, a school of damselfish is visible in the blue distance grazing on plankton. Martens and Niels Lindquist, his colleague at Chapel Hill and co-leader on a ten-day mission to study the impacts of ocean acidification on coral reefs, are doing their own grazing on salads during a rest from the day's 12 hours or so of scuba diving.

The 13-metre Aquarius Undersea Laboratory is located about four miles off the coast of Florida's Key Largo. It's about the size of a large camper trailer, and Martens and Lindquist, along with a team of collaborators, are here to perform what may prove to be the first successful measurements of the way that coral-reef organisms affect the acidity of their own environment. Gathering such information has proven difficult; but, says Chris Langdon, who studies ocean acidification at Florida's University of Miami, "It's the data we absolutely have to have."

Without understanding how the acidity of waters surrounding a reef can change locally, researchers can't properly assess the impacts of ocean acidification, a problem first identified about a decade ago that adds to a litany of other threats to reefs and is expected to worsen in coming decades. "It's a very late and nasty surprise for everybody that we're acidifying the oceans," says Martens, "and there hasn't been enough activity to address it."

MARK SCHROPE

Chris Martens and Niels Lindquist during their ten-day mission to study the impacts of ocean acidification on coral reefs in the Aquarius Underwater Laboratory.

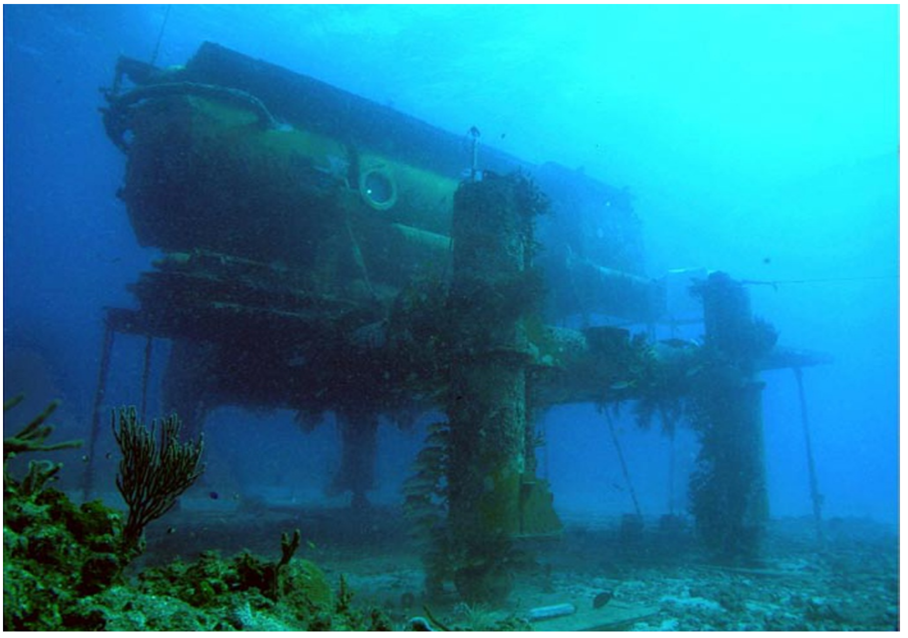
REAL REEFS

The ocean acts as a major sink for CO_2, soaking up some 2 billion tons of the greenhouse gas each year. Though this lightens the carbon load in the atmosphere, once CO_2 enters the ocean it dissolves in seawater to form a weak acid, called carbonic acid. Because it reduces availability of the calcium carbonate compound that corals and other animals use to build their skeletons and shells, the build-up of carbonic acid could severely hamper the ability of corals and other organisms to function.

Since the 1700s, the ocean's acidity, measured in units of pH, has increased in line with estimated atmospheric CO_2 levels[1]. Overall, pH has dropped by 0.1 units from an average, and slightly alkaline, value of 8.2. Although this may sound small, pH is measured on a logarithmic scale, so this represents a 10 per cent increase in acidity. Some research suggests reef building may have already slowed significantly as a result[2]. But the seawater around reefs has natural fluctuations in acidity caused by the photosynthesis of algae and respiration of animals. So separating out human-induced changes in ocean acidity from these background changes is a challenge akin to pulling global temperature increases from the noise of natural variability.

To illustrate why the research group has gone to the trouble to live in Aquarius for nearly four weeks on two separate missions during September and October of this year, Martens dumps out a bowl of candy at the edge of the table. Turning it upside down, he traps a single miniature chocolate bar inside to represent a reef organism confined in an aquarium during a typical laboratory experiment.

Martens explains that much of what researchers currently understand about the effects of increasing ocean acidity on reefs, and reef inhabitants' own pH impacts, is based on experiments with confined organisms. But as is usually the case, reality is more complex than a laboratory construct. So he and his colleagues have brought an arsenal of measuring devices, many of them prototypes under development, which enable never-before-possible *in situ* measurements of reality.



The world's only underwater laboratory, Aquarius, is a 13-metre-long capsule located some 15 metres below the sea surface off the coast of Florida's Key Largo.

"We're moving from this to that," says Martens, pointing from the bowl to another piece of candy out in the open that represents an animal in its natural environment. "We feel like we have to get out here and put our instruments in the real world with all the real variables."

One of the complexities of an actual reef that can't be readily recreated in a laboratory is the interactions of different reef players. During the day, photosynthesizing algae take up much of the CO_2 pumped out by respiring animals and microorganisms. At night, without this counterbalance, CO_2 levels increase, so acidity does as well. Of course, currents and other factors also influence these variations. "No one has a good handle on these local numbers," says Langdon, who was not involved in the Aquarius research but has himself been frustrated in attempts to quantify these effects. But preliminary analysis of the new results suggests Martens and Lindquist's team may finally have the right tools to begin studying local impacts effectively.

SURPRISE FINDS

Though the results are only tentative, some general — and unexpected — trends are emerging. The researchers found an anticipated rise in acidity at night and drop during the day owing to basic biology, which was nonetheless important because it suggested that the equipment was working effectively. The greatest surprise, though, was that they found similar, significant pH changes — equivalent to about one-fifth the bulk ocean change attributed to atmospheric CO_2 — both over the sand and over reefs. "We were surprised that the impact was big everywhere," says Martens.

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>
> Chris Martens

One potential explanation is that there is enough activity by sand dwellers to match the CO_2 production of coral reefs. Another is that organisms such as sponges have a far reach with their CO_2 outputs, a notion that may be supported by the team's work. In past research at Aquarius, the group has measured phenomenal sponge water-pumping rates — as high as 100,000 times their body volume in a day[3]. While actively pumping, sponges and the microorganisms many of them house consume impressive amounts of food, leading to equally impressive CO_2 outputs.

Another surprise find, from dye-release experiments, was that a layer of water just a few centimetres thick above the sediment and the reef remains relatively unmixed with the overlying water column for long periods. Carbon dioxide from sponges and other organisms could be diffusing quickly enough throughout this thin layer to acidify it. If sponges and other organisms are a major influence on the acidity of reef waters, this could be of particular concern because some research suggests that as the well-documented decline of coral cover on reefs around the world progresses, sponges are increasing their prevalence. This could conceivably exacerbate acidification effects, given sponges' high output of carbon dioxide.

This lower water layer is also crucial to understanding the long-term impacts of ocean acidification. If the lower layer is naturally more acidic, it could mean that some reef inhabitants, or at least potential reef inhabitants such as settling coral larvae, may be facing more acidity than predicted as the ocean pH drops. "We're just realizing that this is an important place to make our measurements," says Langdon.

Martens and Lindquist hope that the ongoing research at Aquarius will ultimately become a starting point for more widespread studies. They are also working towards deploying long-term monitoring equipment as part of the larger Aquarius automated observatory facility already established. "That's the dream, that we can actually get into monitoring processes that are important on a longer timescale than people have typically been able to study them," says Martens. "We've got to get started."

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