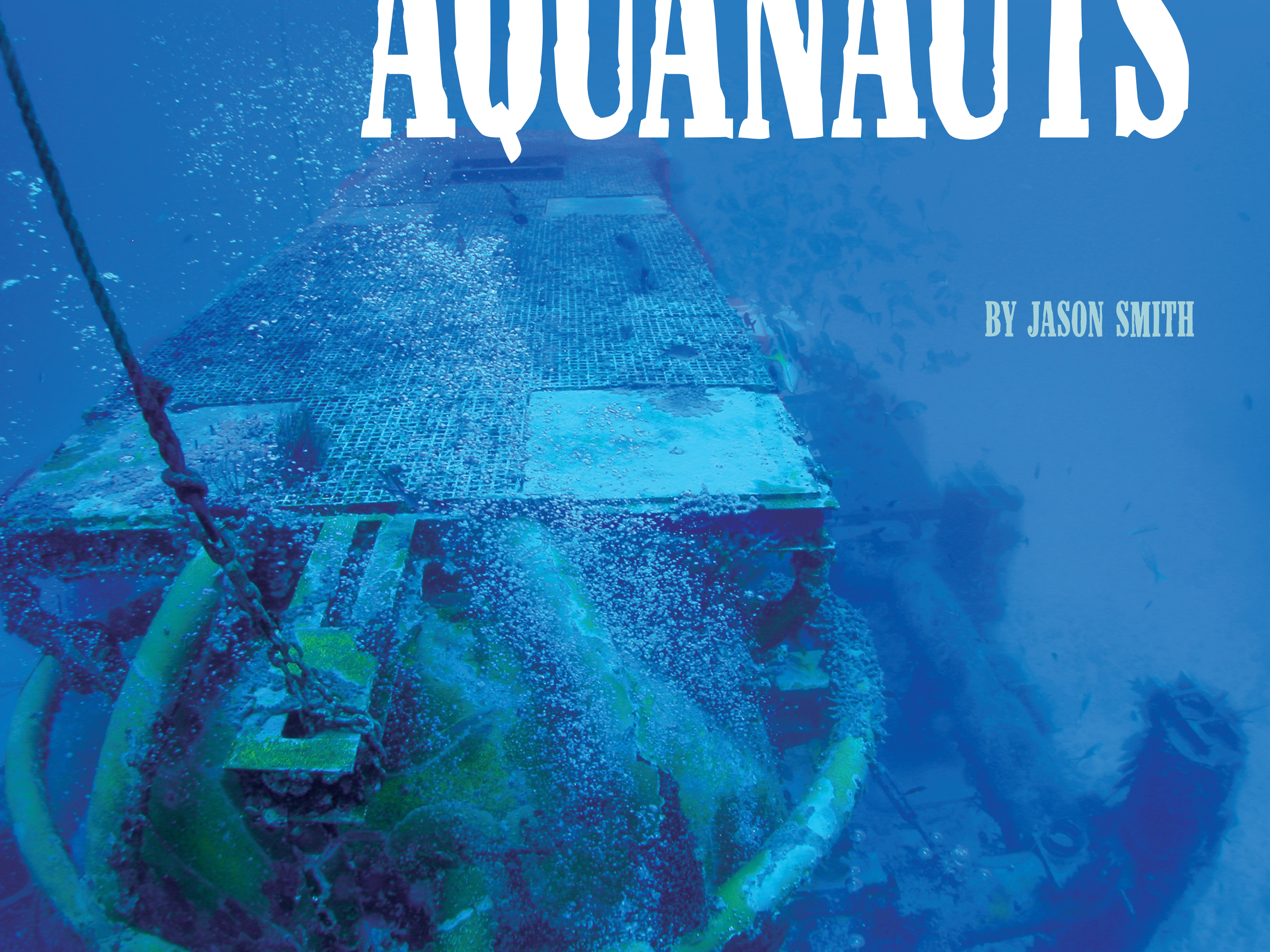
CHARLEY AND THE AQUANAUTS

BY JASON SMITH



SIXTY FEET DOESN'T SEEM VERY FAR, does it? It's the distance from the pitcher's mound to home plate. Two city buses parked end to end. You can stroll it in fifteen seconds.

But today you're going to dive sixty feet to the ocean floor, to the Aquarius undersea laboratory just off the Florida Keys. You're going to live down here for ten days without coming up. Fifteen seconds? Try seventeen hours. That's how long it will take you to decompress and get back to the surface. You've put up with a week of training already. It's August 9, 2004. Tonight, you sleep with the fishes.

Diving down toward Aquarius, you see that it's made up of a long horizontal cylinder with a big box on one end. They call this box the wet porch, and it's like a big bucket of air turned upside down and pushed almost to the seafloor. Swim over to that platform at the bottom of the wet porch. You can stand on the platform and take off your dive gear. Don't worry—from your chest up, you're now in the air that's trapped at the bottom of the wet porch. Grab hold of those stairs, walk up a few steps, and you'll be completely out of the water. Then you can step into the cylinder, where you'll be living, eating, and sleeping.

That fresh air you're breathing is pumped down from a buoy on the surface. But the air pressure inside Aquarius is the same as the water pressure outside: about three times greater than surface air pressure, says Chris Martens, a marine sciences professor and the coleader of your aquanaut team. Your voice sounds higher down here. Soon your blood will become saturated with nitrogen. Unlike conventional diving, when you can only stay down forty minutes or so, you'll have virtually unlimited dive time. "But you're about as pressurized as the soda in a coke bottle," Martens says. Come to the surface too fast, he tells you, and you'll be just like that coke when the top gets popped: "You'll fizz."

You're now an aquanaut, along with Martens; coleader Niels Lindquist, a professor of marine sciences; Jeremy Weisz, a graduate student in marine sciences; Meredith Kintzing, an undergraduate in marine sciences and biology; and Thor Dunmire and Roger Garcia, who will be your Aquarius technicians. You'll squeeze into Aquarius for ten days. See those cameras and speakers? That's so the Aquarius support team, up on the surface, can hear—and sometimes comment on—everything you say. They'll be able to see almost everywhere inside Aquarius and many places outside it. Your only real privacy will be behind the shower curtain. You're now on a reality show, 24/7. Living so deep for so long might net you anything from nitrogen narcosis to swollen fingers to outbreaks of an itchy rash called "the funk." Be careful down here—a medical officer will make daily visits, but major surgery is best scheduled when you're topside.

Oh, we forgot to tell you one thing: it's hurricane season.

Relax. Hear that sound like rain on the roof? That's the pistol shrimp snapping their little claws. Sleep tight.

MISSION JOURNAL 1: NIELS LINDQUIST

Conditions can change quickly on Florida coral reefs. Two days before we splashed down, the water over Conch Reef was beautiful—warm and clear top to bottom. Today, however, the water looked very different. It was difficult to see my buddy, Jeremy Weisz, when he was only twenty feet away from me. No telling what we'll wake up to tomorrow.

In the mid-1990s, Chris Martens came down to the Keys to dive. He'd grown up here, knew the water by heart. But he hadn't dived here since the '70s.

Let Martens fill you in on that dive: "I was shocked at how different the reefs were in just twenty years," he says. "All the branching corals were gone—there were brain corals left, but sponges had sort of taken over. Big barrel sponges as tall as four feet. Lots of rope sponges." Sponges, you learn, are hardy and grow relatively quickly. Coral, on the other hand, grows more slowly, and it can't tolerate big temperature shifts and big spikes in nutrients such as nitrogen *(see* Endeavors, *Spring 2004, "Taking the Pulse of a Reef").*

Martens tells you he took some sponge samples home on a lark. Sponges make a living by filtering particles out of the water, so Martens figured they could tell him something about what was happening to corals on the reef *(see illustration, page 17).*

About half of Martens' sponge samples had normal levels of nitrogen. But the other half were depleted in one isotope of nitrogen, N-15, and much more enriched in another, N-14. This second group of sponges also happened to be loaded with bacteria—they're called bacteriosponges, in fact, and up to 30 or 40 percent of their mass can consist of bacteria, Martens says.

So you've come to Aquarius with the rest of the aquanauts to try and get a handle on what these sponges are up to. What role do they play in the nitrogen cycle on the reef? Are they taking nitrogen from their food and from ocean water and converting it into forms of nitrogen that are putting corals out of business? Or are the sponges helping the reef?

Left: The Aquarius underwater research laboratory on Conch Reef, four miles off Key Largo along the Florida Reef Tract. Photo by Chris Martens. **Right:** Chris Martens in the Gazebo, a small structure separate from Aquarius. The aquanauts can regroup here if an emergency makes Aquarius uninhabitable. Photo by Jens Kallmeyer.

MISSION JOURNAL 2: CHRIS MARTENS

Got up early after a good night's sleep—we always sleep well after a diving day. Had my Kix with milk, then it was off to do our first full experiment with living sponges. I casually check my always-faithful meter for measuring oxygen levels…surprise! The oxygen meter is dead, absolutely stone dead. After an hour's work I still can't find the problem. We decide to send the meter ashore. Sometimes, actually often, things don't go as expected, and it's good to have a backup plan. Plan B is to conduct a survey of the amount of sponge biomass on the seafloor. Meredith and I suit up and head out. Before the day is done, we've conducted four sponge surveys. We head in at 7:30 p.m. On the way back we have some extra time for a little fun in the darkening water column. I flash around our new halogen high-intensity beam lights. The fish go bonkers.

At Aquarius we peer under the main lock at *beautiful, bright-orange corals which have begun their nighttime feeding. Their tentacles flow with the water movement—a continuous dance that brings them into contact with tiny food particles that they capture with a graceful withdrawal of each tentacle. Time to go in and get a shower and some chow.*

To get new nitrogen into an ecosystem, Martens tells you, something has to "fix" it. That is, something has to take gaseous nitrogen—which is found in the air, but there's also plenty of it dissolved in ocean water—and convert it into nitrate or ammonia. Certain plants, such as peas or alfalfa, are hosts to bacteria that fix nitrogen; that's one way that new nitrogen gets introduced into soils.

Are sponges fixing nitrogen and fertilizing the reef? Are they killing the corals?

"That's a real shocking idea," Martens says, "because everybody in the Keys is worried about nitrogen coming from sewage out to the reefs. And here we are claiming that it's possible that something that lives out there naturally is adding new nitrogen."

Martens has been to Aquarius before. In 2003, he brought graduate student Melissa Southwell down here, and she brought along a piece of equipment she built with the help of Martens and Howard Mendlovitz, an engineer in the Department of Marine Sciences. Southwell set up four rows of six rotating cylinders, each of which housed a piece of sponge in artificial ocean water, along with some nitrogen gas, enriched in its N-15 isotope.

If the sponge bacteria were fixing nitrogen, the researchers would expect to see some of the N-15 isotope converted into sponge tissue. After Southwell's sponges bubbled away happily inside their cylinders for a day or so, the researchers brought all them back to Carolina to see how much of the N-15 showed up.

They didn't find hard evidence for a lot of nitrogen fixation in those experiments, but they still can't definitively say that the sponges aren't fixing nitrogen and harming the reef. So they'll do more experiments.

In the meantime, Niels Lindquist wants to find out how much water sponges can filter over a given period. It's not enough to just say that sponges are adding nitrogen to or removing nitrogen from the reef. If you want to prove whether sponges are affecting the reef, you have to know the rates at which they're taking up nitrogen and releasing it.

"But imagine the difficulty of measuring the pumping rate of a sponge that has all these intake holes and all these oscula out of which water is pumping," Martens tells you. "They're pumping water like little bilge pumps."

But Lindquist has a device called an Acoustic Doppler Velocimeter (ADV) to figure out how much water a sponge can pump. He sets it up over a sponge, and it sends out an acoustic signal that gets bounced off any particles that happen to be in the water the sponge is pumping out. The sponges are filtering water so well, though, that there aren't enough particles coming out for the ADV to pick up. So Weisz and Lindquist improvise, trying to figure out what kind of particles they can add to the water flow around the sponges.

MISSION JOURNAL 3: JEREMY WEISZ

After much experimentation, we have settled on a mixture of baker's yeast in seawater. Unfortunately, we discovered an inquisitive grunt happily feeding away on the slow stream of yeast flowing out of our delivery device. He soon left, though, leaving only a small blip in our data set for the day. Our afternoon excursion ended with me interrupting some jacks roaming the reef. We have now finished our dinner, and will soon gather at the galley window to watch fish feed.

Somewhere between last year's Aquarius mission and this one, Southwell asked a new question: instead of fixing nitrogen and adding it to the reef, what if the sponges were getting rid of nitrogen?

It's possible, Martens tells you, that the sponges are taking fertilizer nitrogen—the ammonia and nitrate that's dissolved into the water around them—and converting it back into nitrogen gas.

Melissa Southwell has built a second set of rotating cylinders, and they're down here with you. Kintzing is going to help Martens run the experiment using Southwell's setup. It isn't going to be easy—the water's been

Far left: This stovepipe sponge *(Aplysina sp)* may one day yield treatments for cancer and other diseases.

Top center: Piggy nose sponges *(Agelas schmidti),* here surrounded by orange lumpy encrusting sponges *(Ulosa ruetzleri),* which tend to grow on the dead spots of reefs.

Bottom center: A branching vase sponge *(Callyspongia vaginalis).* In strong currents, this sponge will grow into fan or vase forms instead of the tubular form seen here.

Photos by Chris Martens.

SOAKING UP SPONGES

Sponges almost constantly filter water—and lots of it. For example, Weisz and Lindquist found that a liter of tissue for one sponge species could filter up to fifty thousand liters of seawater per day. That's enough to fill a decent-sized swimming pool.

Sponges are simple animals—they don't have brains, organs, or muscles—but they're very good at what they do. They've been filtering Earth's ocean water for at least five hundred-million years. Some scientists now believe that sponges are the earliest, most primitive multicelled animals.

There are sponges shaped like barrels, fans, tubes, and cups. Some resemble bushes. Some sponges arm themselves with microscopic spikes, and some produce toxins that are beginning to be studied as antitumor and anti-inflammatory drugs.

In 1986, Calhoun Bond found that some sponges can move. Bond was at Carolina at the time and now teaches at Greensboro College. He used time-lapse microscopy to show sponges moving up to four millimeters a day in the laboratory.

Martens says a surface to attach to is the big limiting factor for sponge life in the oceans. But sponges are opportunistic, and will grow wherever they can latch on to something solid.

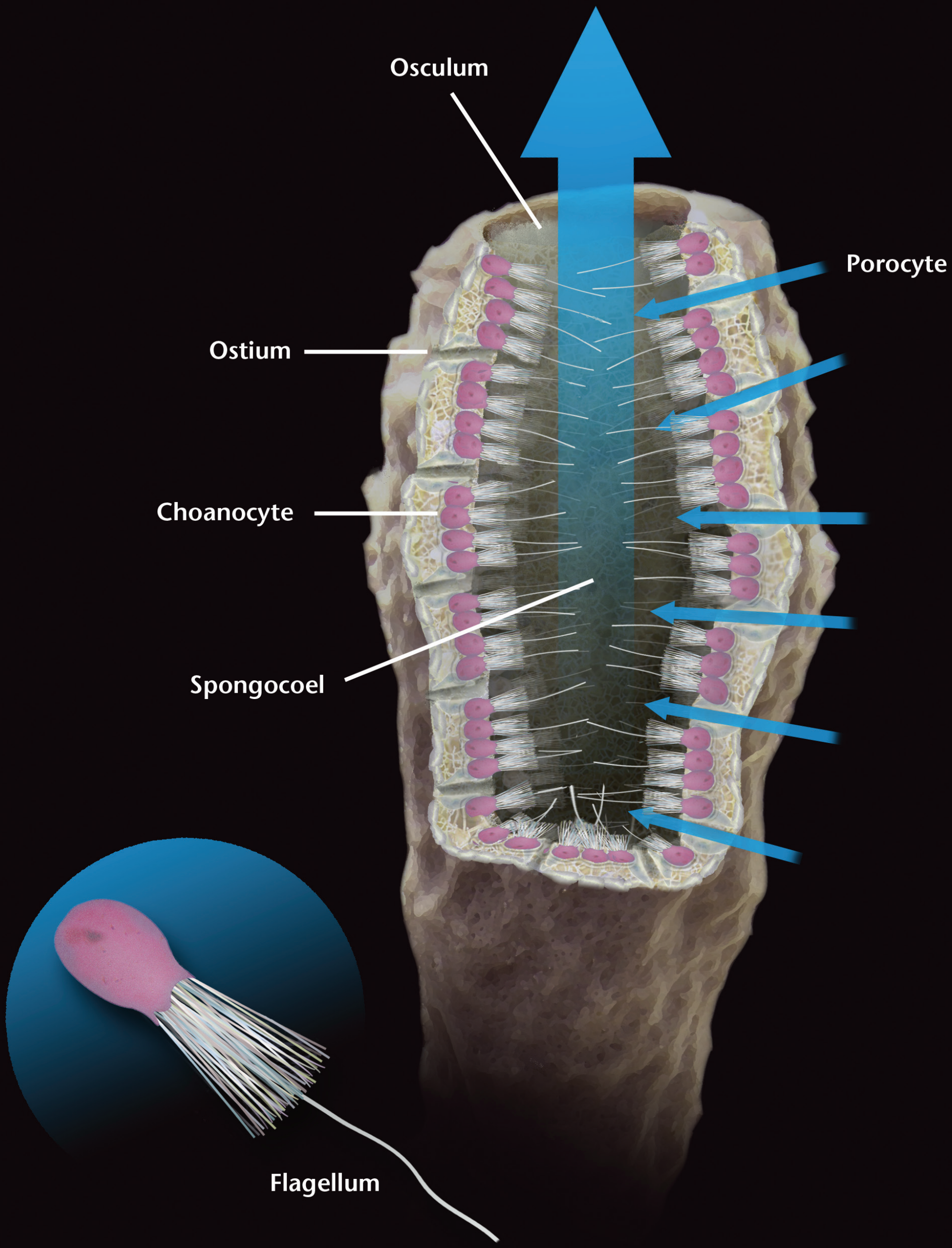
Certain fish, such as rock angels, will eat sponges. But Martens warns that "living sponge is not too delectable. I actually tried to taste one once—you don't want to go there."

Sources: McClintock, Jack. "This is Your Ancestor," *Discover,* November 2004; Chris Martens; Niels Lindquist.

THIS ILLUSTRATION shows the most primitive—and simple—way that sponges go about their business. Inside the sponge, specialized cells called choanocytes use their flagella to pump water through the sponge's pores. After the choanocytes comb the water for food, the water exits the sponge through the ostia and osculum.

In most modern sponges, the choanocytes are arranged in a more complex and convoluted canal system within a thicker sponge wall or body. This allows the choanocytes to filter particles from the water stream more efficiently, and helps flush wastes from the sponge body through the osculum.

Illustration by Neil Caudle.

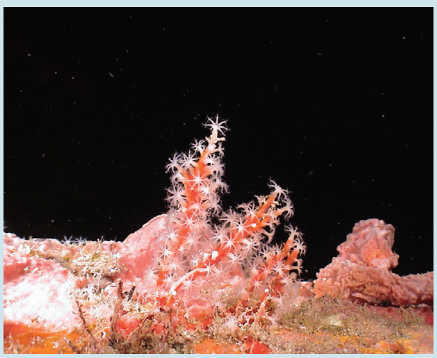


Top: While fairly uncommon on natural reefs, this white telesto *(Carijoa riisei)* is one of the first corals to inhabit shipwrecks and artificial reefs.

Middle: This orange cup coral *(Tubastraea coccinea)* is considered an endangered species.

Bottom: The white star-shaped objects are living coral polyps, which come out of this plate coral *(Agaricia sp.)* at night to feed.

Photos by Chris Martens (top and middle) and Jens Kallmeyer (bottom).



murky since you got here. Currents are shifting. Something has gotten the ocean worked up.

MISSION JOURNAL 4: ROGER GARCIA

I woke up this morning to find the water just as turbid as day one. Leaving the safety of Aquarius, I find myself in a two-knot current, with poor visibility, surrounded by predators, and ready to perform hard labor for six hours. To work underwater in these conditions is like working on land when you are cold, tired, hungry, blind, and have one hand tied behind your back. You gotta love it—I do.

Lindquist and Weisz go out to do more work with the ADV. Around 1:00 p.m., they come back inside to download their data, change their film, and have lunch. Lindquist checks some weather web sites: two big storms brewing in the Caribbean sea and the Gulf of Mexico. It's not what he wants to see.

Lindquist and Weisz head out for a second dive and work a few hours. On the way back, they pass Martens and Kintzing, who are doing their sponge surveys. Lindquist goes back into Aquarius, showers, then checks the weather again. The storms are getting bigger, and moving closer to Key Largo. Roger Garcia tells you that one of the storms, Hurricane Charley, might force you to abort the entire mission.

Your group is getting a little worried. Remember, you need seventeen hours to decompress and get back to the surface.

Martens has been as close to hurricanes as he wants to get. When he was a kid, Hurricane Donna wrecked his dad's fishing boats. He tells you about being in seventeen- or eighteen-foot seas in the Gulf of California, aboard the 240-foot *Atlantis 2*, which rose up out of the water with every passing wave and slapped down at the bow, like a little sailing skiff.

You don't want to ride a hurricane out down here, either: If you get twenty-foot waves, your effective water depth yo-yos from seventy to fifty feet in a matter of seconds. Aquarius would have to be locked up tight, otherwise your ears couldn't handle the changing pressure. And there's the off chance that a window could blow or a hatch could fail.

Talk at dinner turns to the storm. "If you were to rupture any of these windows," Martens says, pointing around you, "the suction pressures…no one would be able to survive that kind of pressure change. It would be impossible." You glance at your fellow aquanauts. "Anyway, they wouldn't be able to rescue you in twenty-foot seas," Martens says.

Charley is only getting more dangerous. You don't know it now, but the storm will eventually kill more than thirty people. Even so, your aquanaut team votes unanimously to stay down. You look around and realize you're getting to like it down here. You're going to miss seeing BOB—the "Big Old Barracuda" who has come to visit at the porthole every day. And the experiments aren't finished.

The Aquarius topside team isn't having any of it, though. They decide to start decompression first thing in the morning. You start packing your gear. Garcia and Dunmire secure Aquarius and get ready to turn it into a decompression chamber.

In the meantime, the National Oceanic and Atmopsheric Administration has you on its web site as the top story of the week. *Good Morning America* has gotten wind of the fix you're in, and you get a mention on the show. Kintzing isn't impressed, though. She says she'd trade this little bit of fame for more time in Aquarius any day.

Seventeen hours later, you're ready to come up. Well, maybe not ready, but you're going to come up whether you like it or not. After Martens is done goofing around—right now he's standing in front of the Aquarius camera holding up a sign that says "Hell no, we won't go"—he explains how you'll get back to the top:

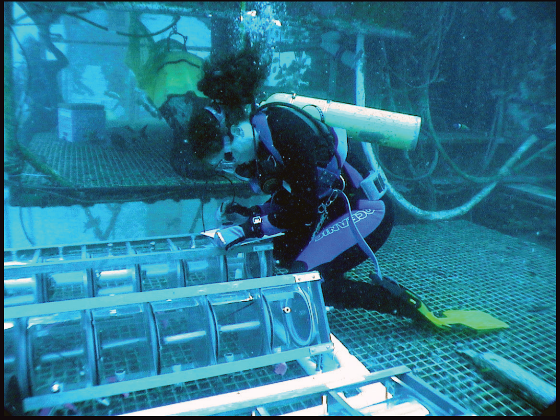
"All you get is a little handheld air tank with a regulator attached to it, your mask, snorkel, and fins, and your bathing suit—and nothing else." He laughs. "Then you just head right for the surface. It's sort of like being born again, you might say."

Aquarius is owned by the National Oceanic and Atmospheric Administration (NOAA). It is administered through NOAA's National Undersea Research Program and operated by the University of North Carolina at Wilmington's National Undersea Research Center. Learn more about Aquarius at www.uncw.edu/aquarius/. Aquarius is currently located in the Florida Keys National Marine Sanctuary. The research in this story was funded by the National Science Foundation and the National Undersea Research Center.

Above: These schoolmaster snapper *(Lutjanus apodus)* haven't really lost track of which way is up. The top of the photo shows reflections of the snapper as they swim under the Gazebo, where trapped air creates an underwater ocean "surface" that mirrors the fish. Photo by Chris Martens.

Right: Melissa Southwell's array of rotating cylinders. Each sealed cylinder contains artificial ocean water, a sponge, and a bubble of nitrogen gas in its N-15 isotope. The cylinders rotate to mix the nitrogen into the water and to expose all parts of the cylinders to the same amount of light. After an incubation period, Southwell removed the sponges to find out how much N-15 showed up in sponge tissue. Photo by Chris Martens.

MISSION JOURNAL 1, 2003: MELISSA SOUTHWELL



The area around Aquarius seems like a different place at night—fish that were swimming in lazy circles in the daytime go into hyper-drive, darting in erratic patterns after their prey. I must say it's an eerie feeling to be working and have shadows passing over me as the fish circle overhead. Each time it happens, the theme song from Jaws *plays in my head.* Duh nuh…duh nuh…duh nuh duh nuh duh nuh. *It's enough to make me laugh into my regulator, and almost enough to make me forget about the sensation of a cold wet suit at four in the morning.* Photo by Chris Martens.