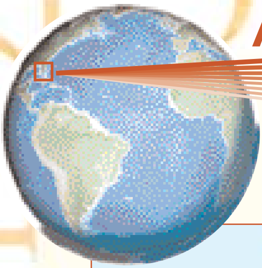
WORLD TOUR

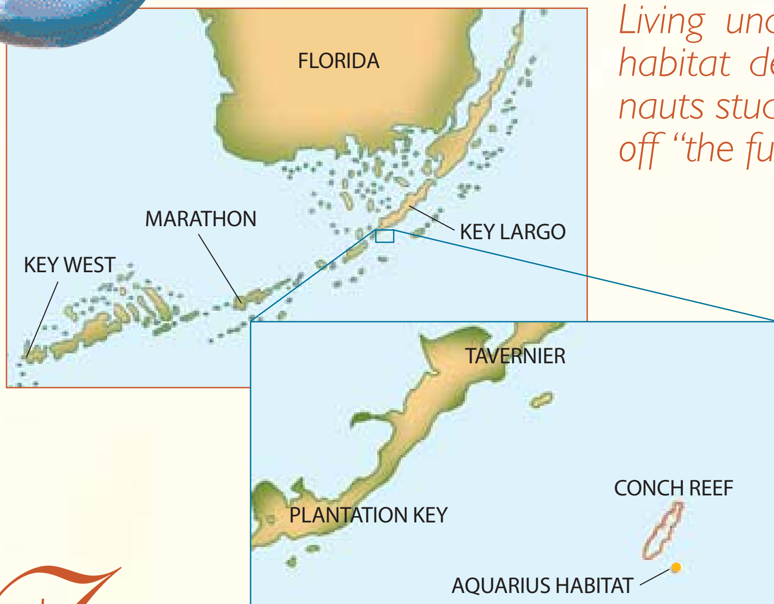


ATLANTIC OCEAN:

Ten Days under the Sea

Living underwater in the world's only habitat devoted to science, six aquanauts studied juvenile corals and fought off "the funk"

by Peter J. Edmunds



LAURIE GRACE *(map)*; WILLIAM F. HAXBY *(globe)*

It was seven on a July morning, and I already felt like I had been awake for hours. I was standing with my research team in a cigarette-style motorboat speeding toward Conch Reef off Key Largo, Fla. When we reached our destination on the reef, we would descend into the clear, dark-blue water and stay there for rather a long time.

We were about to start our first mission in the Aquarius underwater habitat, a six-person research station situated 6.5 kilometers (four miles) off Key Largo and 15 meters below the waves. For the next 10 days, we would be aquanauts, living every marine researcher's fantasy: we would spend as many as six hours a day working in the water and then retire to a warm, dry, comfortable shelter for meals, discussions, relaxation and sleep.

The powerful, streamlined boat sliced easily through the morning swells as it pushed eastward toward the rising sun and the support barge, which was anchored directly above the habitat. My team and I had gone through a lot to get to where we were. There had been a year of planning, four days of intensive training and, in my case, a lifetime of ambition to work underwater as a marine biologist. Still, I couldn't help thinking about the things I would miss while living underneath the sea: sunshine, fresh air, open spaces, even the squadrons of pelicans that soared silently over the boat.

My teammates, pensive and quiet, seemed to be ruminating on much the same theme as we arrived at the barge, moored and exchanged our dry shirts and sandals for damp wet suits and ungainly fins. After years of use, the scuba gear I donned had the comfort of well-used tools, except for one critical omission: my familiar red face mask no longer had a snorkel attached to the strap. The most basic of my regular equipment was conspicuous in its absence, reminding me that where I was going, the surface would no longer provide a safe haven from trouble.

In the realm that my team and I would shortly enter, the Aquarius habitat would be our only refuge and the surface a dangerous place where we could die in minutes. Within 24 hours of submerging, our bodies would become saturated with nitrogen gas. In this state, a rapid return to the surface would induce a severe and possibly crippling or even fatal case of decompression sickness, better known as the bends. Although I had long been aware of this fact, I realized there was no turning back as I sat on the diving platform at the stern of the boat, straining to prevent myself from being pushed into the water by the heavy set of twin tanks on my back.

Yet as I plunged into the water, I was freed from my concerns and from the weighty terrestrial world. Finally, I was able to focus my attention on the immediate goals of my research and the excitement and challenges of living underwater.

My four scientific team members hovered below me as I adjusted my mask, purged the air from my buoyancy compensator and sank below the surface. Creole wrasses, barracuda and other fish darted in and out of my peripheral vision. I exchanged an "OK" sign with my buddy, and we descended through a fine snow of planktonic organisms to the hidden reef nearly 17 meters below.

I had started hundreds of dives in similar fashion, but this one was different. Instead of surfacing after a brief visit, my colleagues and I would be down as deep as 30 meters for nearly three hours, completing three times the tricky maneuver of exchanging empty scuba tanks for full ones at depth.

As I continued my descent, the reef be-

DAN BURTON

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AQUARIUS HABITAT sits on the seafloor off Key Largo, Fla. The white "gazebo" in the foreground (*left*) is full of air, offering a temporary refuge for divers. Author Peter Edmunds (*wearing eyeglasses in photograph above*) peers out of the bunk-room porthole with aquanauts Dione Swanson and Sean Grace.

neath me took shape, becoming a rolling landscape of underwater hills and valleys cloaked in a forest of sponges, stony corals and soft corals waving in the current. As on previous occasions, I was struck by the odd similarity between this reefscape and a frosty winter scene in my native England.

Our dive location, known simply as the northeast site, was half a kilometer from the habitat and formed a blunt spur at the end of one of the rope "highways" secured to the sea bottom. Their purpose was to provide guidance to the habitat in the event of strong currents, poor visibility or impaired vision caused by the loss of a face mask. Closer to the bottom I saw the edge of the reef sloping down to more than 40 meters' depth; the mosaic of coral colonies, sediment and algae that covered much of the reef surface; and the filling station where I would soon grow accustomed to swapping my scuba tanks.

Here among the corals, being chased incessantly by feisty and territorial but (fortunately) small damselfish, we started to count and measure the small juvenile corals that were the subject of our research. A fair amount of our underwater work involved searching for these khaki-brown, golf-ball-shaped objects, which are known as coral recruits, nestling among tufts of algae.

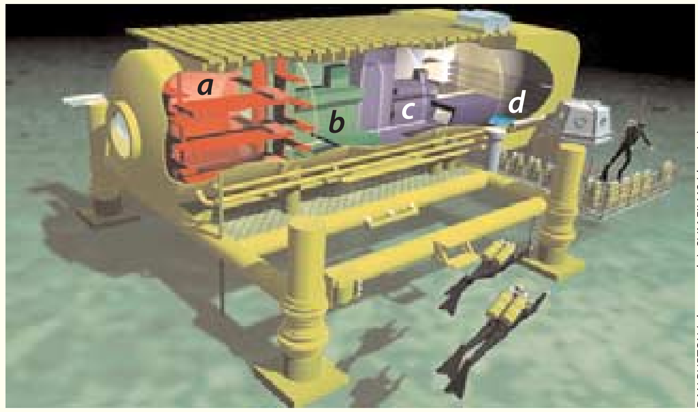
I had my first ideas about this project in the late 1980s, when I was struck by the devastation wreaked by Hurricane Hugo on Caribbean reefs, particularly those off St. John in the U.S. Virgin Islands. It had taken nearly six years for those reefs to recover. My surveys suggested that many of the coral recruits that had managed to survive by attaching themselves to solid surfaces did so in cracks and on the undersides of ledges and pieces of rubble. I began to wonder whether this kind of settlement, in so-called cryptic locations, provided a springboard for growth onto the open reef. During our first mission in Aquarius in July 1995, my colleagues and I would begin trying to find out.

Although I did not realize it at the time, those 10 days under the ocean would also alter the direction of my research over the next several years. Experiments I began in 1995 during my stay in Aquarius were completed the next summer, when I returned to Key Largo. I was not able to use the habitat in 1996, so I tended to those experiments by diving from the surface. The experience of working on similar experiments from two different diving environments drove home to me the value of saturation diving, which offers vastly more time in the water.

Using the tools and technologies that I began working with in 1995 and 1996, I started a new set of experiments in the summer of 1997. As in 1996, I operated from the surface. As this article is being prepared for publication in the summer of 1998, however, I am planning a second saturation mission in the Aquarius habitat. I will lead a team with seven other researchers, four of whom will be saturating with me in the habitat. We will be following up on the work begun in 1997 on a malady called bleaching, which since the mid-1980s has harmed or killed countless corals all over the world.

Water View

It was at the end of that first dive in July 1995 that we first entered the 13-meter-long pressurized cylindrical chamber that would be our home for the next 10 days. People who have never been inside the Aquarius habitat invariably believe it to be



DAN BURTON (*photographs*); SLIM FILMS (*drawing*)

MAIN QUARTERS of Aquarius habitat (*above right, bottom*) include a bunk room (*a*), in which six beds crowd the walls, a kitchen area with a small table under a porthole (*b*), a small laboratory area (*c*) and a "wet porch" (*d*), which serves as a kind of vestibule between the main quarters and the sea. Aquanaut David Carlon spends a quiet moment in the bunk room (*above left*). Edmunds and aquanauts Swanson and Grace relax in the kitchen area after lunch (*above right, top*). Christopher Borne, a member of the support crew, arrives in the wet porch entrance, or "moon pool," to deliver the day's lunch to Kenneth Johns (*right*).

damp and claustrophobic, which it is not. The ocean merges with the habitat through a "moon pool" in a wet porch. This porch is joined by a pressure door to a main living and working space and, beyond it, a bunk room, in which six beds crowd the walls. Other than the wet porch, the habitat is air-conditioned, with decor dominated by stainless steel, blue carpeting and stunning, watery-blue light. Just off the wet porch, in the main section, the laboratory area accommodates a submarine-style toilet and a bench with computers and digital displays for marine sensors. From this room, we could collect data from corals in their natural environment and talk with divers in the water as they positioned sensors on the reef, for example.

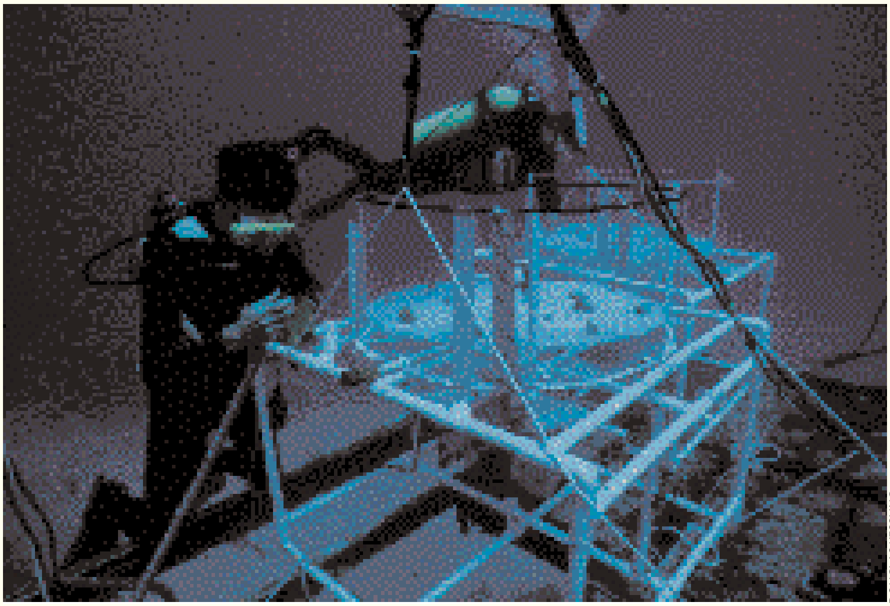
The rest of the main room was where we relaxed, ate meals, discussed plans and, whenever possible, allowed ourselves to be distracted by whatever was happening outside the largest porthole in the habitat. Though strangely analogous to visiting an aquarium, our observations sometimes left us unsure whether we were watching or being watched.

The main room was also where we decompressed at the end of our mission. This is the great advantage of saturation diving: once the body is saturated with nitrogen, decompression—the period required to bring the diver gradually back to surface pressure without inflicting decompression sickness—is the same regardless of how much time has been spent underwater. During decompression, the main room was sealed off from the wet porch and, over a period of 16 hours and 30 minutes, the pressure was slowly reduced to one atmosphere. We could then swim up to the terrestrial world without ill effects.

During the 1995 mission, our days began with a three-hour dive, followed by lunch in the habitat and a second dive of similar duration in the afternoon. On most forays we swam about 500 meters along the reef. When the currents were strong, we hauled ourselves hand over hand along the rope highways affixed to the sea bottom. At one end of each line we found spare scuba tanks and an air-filled dome; we could stick our heads into this hemisphere to eat fruit or candy and, of course, talk science with our buddy.

The lengthy periods in the water inevitably made us feel a greater affinity for the resident marine life than for our fellow humans visiting regularly from the surface with food and supplies. These feelings were accentuated at night, when we made short

CORAL INCUBATOR was designed and built by the author, who kneels to the left of it. At the top, a plexiglass collar surrounds a rotating table, on which corals can be exposed to different temperatures, water-flow rates and levels of ultraviolet light.



DOUGLAS KESSLING

forays into an inky darkness alive with silvery tarpon and big, inquisitive barracuda.

Although we worked in warm, tropical waters, our long dives left us bone-tired and so ravenous that even a dwindling chocolate supply could trigger quite an argument. Fortunately, however, hefty dinners were delivered daily and cheerfully consumed against the backdrop of a teeming ocean, along with conversation that dwelt on marine creatures and our life underwater.

In the early evenings, as the effects of fatigue and nitrogen narcosis seemed to intensify, extraneous subjects occupied more of our discussions, and we found something to laugh about on almost any topic. On one occasion, the discovery that one of our team had developed an outbreak of "the funk," an unpleasant rash brought on by dampness and abrasion, caused our select scientific team to run around erratically, laughing so hard that for 10 minutes we were unable to answer the worried calls from the surface crew. Although we were warned that such behavior is common in divers whose tissues are saturated with nitrogen, we did not realize how much harder it would make the planning and execution of our research.

During many of our lengthy forays along the reef, we painstakingly quantified coral recruits in both conspicuous and hidden, confined locations as deep as 33 meters. Our working hypothesis—that such cryptic locations provided a springboard for coral growth onto the open reef—seemed unsupported by the data. Instead of finding juveniles crammed disproportionately into cryptic locations, we found that more than half of them were on open, horizontal surfaces, up to a third were on vertical surfaces and only the remainder were hidden in caves and cracks. Most of the areas that we examined contained an average of six juveniles per square meter.

Cryptic locations may still be important; it is possible that the hidden juveniles have higher survival rates than those on open surfaces. To investigate this hypothesis, we permanently marked juveniles to determine their survivorship between 1995 and 1996, when we visited the same sites in dives from the surface. Because many of these sites were at a depth of about 30 meters, our forays were necessarily short. Although we maximized our bottom times by breathing a mixture of 64 percent nitrogen and 36 percent oxygen, we were allowed only about 35 minutes at depth, during which time we frantically brushed away a year's worth of sediment and algae to find the aluminum tags used to mark the corals. Once they had been found, we noted whether the corals were alive or dead and then used plastic calipers to measure the diameter of the living corals to determine their growth rates.

Fond Memories of "the Funk"

Though essentially simple, these tasks became time-consuming and difficult when undertaken under the duress of short bottom times and with fingers swollen and abraded by repeated brushing against various rough surfaces. Between dives, we spent hours on the surface, rolling around in the swells or baking in the sun, waiting until it was time to enter the water again. Feeling alternately nauseated and fried, we began to feel that "the funk" and lack of sun were a small price to pay for the opportunity to live underwater and to have almost limitless bottom time.

As I write these words, I am deep (so to speak) into the preparations for my second mission in the habitat. My team and I will focus on coral bleaching, an increasingly common disease in which corals lose their algae, with which they live in symbiosis and without which they cannot survive. Bleaching is caused by a combination of several factors, including high temperatures and increased levels of ultraviolet radiation. Because these environmental conditions are intensifying and have probably been fostered by human activity, coral bleaching is one of the severest threats now facing the world's reefs.

My colleagues and I will use incubation chambers designed and built in my own garage for the purpose of exposing corals to precisely controllable temperatures, water-flow rates and levels of ultraviolet radiation. We hope to gain new insight into how these factors act together in nature to cause coral bleaching.

The tasks involved are daunting: simultaneously running 14 pumps, six ultraviolet lamps, a water heater, a water chiller and numerous sensors and meters. Even the veteran professional divers of the Aquarius support team have shaken their heads in consternation at the prospect of using so much alternating electric current and having so much electrical wiring in the water. Nevertheless, my confidence that the incubators will work is based on trials we ran in the summer of 1997. We deployed the equipment from a boat moored over Conch Reef and tested it with power supplied from the surface.

After a long week of broiling-hot weather, I dived down to the unit and verified that it was actually receiving hot water and controlling water flow and ultraviolet light. The incubator was resting on one of the supports for the Aquarius habitat at a depth of 15 meters, with a curious barracuda hovering a few meters away. Sitting there under its tangle of umbilical wires and hoses, the incubator might have seemed an ungainly contraption to some. But it sure was beautiful to me.

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