Science at Hydro-Lab

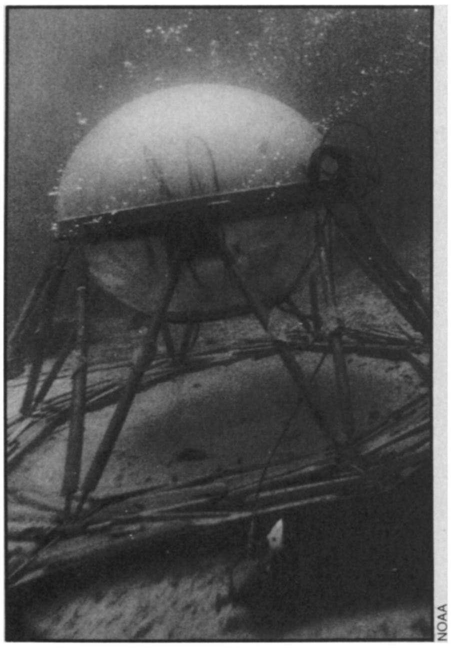
The most used habitat hosts a major new project

BY JOHN H. DOUGLAS

Long after its larger, fancier competitors have been dispatched to the obscurity of a naval maintenance yard, the tiny Hydro-Lab undersea habitat continues round-the-clock operations on a coral reef a mile off Freeport, Bahama Islands. Called an "underwater pup tent" by its inhabitants (see accompanying story), the simply designed steel cylinder—16 feet long by 8 feet in diameter, with a four-foot acrylic end window—was first used in 1966 and has amassed more seabottom time than any other habitat in the world.

If anything, the pace of activity is picking up. During April, four successive teams of diver-scientists, working under joint public and private sponsorship, launched a concerted assault to explore the virtually unknown deep reef environment along a steep underwater cliff near the Hydro-Lab. Called Project SCORE (Scientific Cooperative Operational Research Expedition), the exploratory effort was divided into four week-long missions, aimed respectively at studying fish, coral, algae and reef geology along the cliff to a depth of 250 feet (SN: 4/5/75, p. 221).

Each mission team included three scientists, accompanied by a diving technician from the Harbor Branch Foundation, one of the SCORE sponsors. While two scientists swam together along a submerged lifeline, which provided air and communications to four "talking stations," a third scientist could board the deep submersible Johnson-Sea-Link to

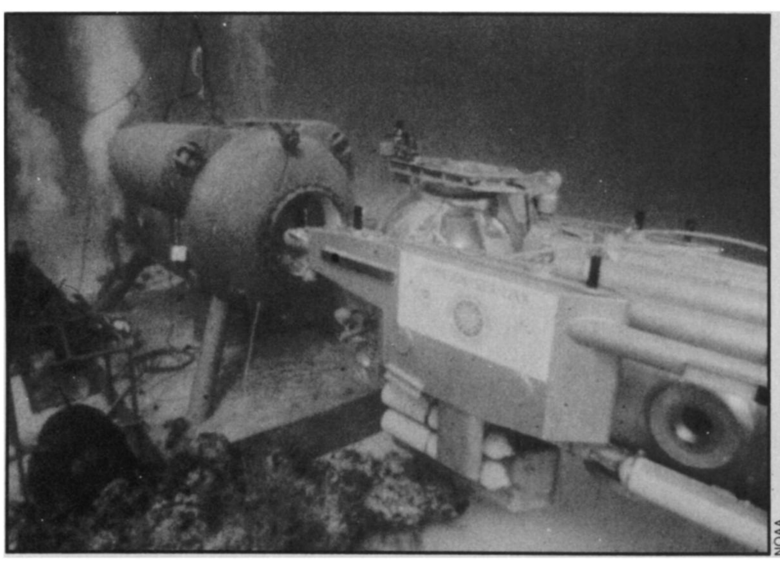


Sub-Igloo that saved a diver's life.

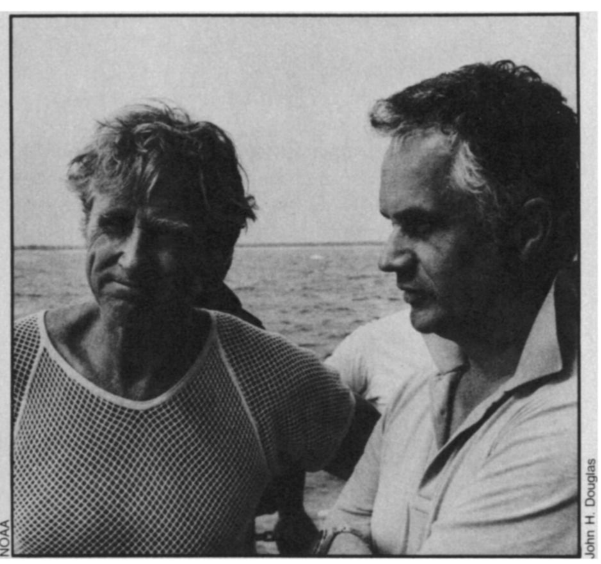
ride to the undersea cliff, locally called The Ledge, some 700 feet away. The free divers could spend up to an hour exploring The Ledge to a depth of 200 feet, before slowly returning to the Hydro-Lab, with three decompression stops along the way, to prevent formation of nitrogen bubbles in their bodies, which cause "the bends." The inverted acrylic hemispheres filled with air, called "talking stations," and a larger "Sub-Igloo," in which four men can sit, allowed the divers to decompress in relative comfort, while talking about the mission.

Meanwhile, aided by the crew of Sea-Link, the third scientist was able to descend to 250 feet, using a "hooka" breathing apparatus—a face-mask and umbilical leading to the Sea-Link, which rids the diver of the necessity of carrying scuba gear and permits continuous two-way communication. After 45 minutes at this depth, the diver would return to the submersible for decompression en route to the Hydro-Lab. After one of these deep dives requiring decompression, no further excursions below the depth of Hydro-Lab would be permitted until the next day, and the Sea-Link was returned to its cradle on the aft-deck of the attending surface vessel, R.V. Johnson.

Previous knowledge of the deep reef environment has come largely from the work of Thomas F. Goreau and his colleagues, exploring the warmer sourthern waters off Discovery Bay in Jamaica. Goreau found that some types of coral are active reef builders below depths most researchers thought uninhabitable and that the rate of reef building depends on the amount of light received by tiny algae that live symbiotically with the coral. Later, new species of stony coral and calcareous algae (important structure and sand producers) were discovered, together with a



Deep submersible Johnson-Sea-Link pulling up to Hydro-Lab.



Bridges and Miller aboard the R. V. Johnson.

Camping Out Undersea

Few scientists still have the opportunity of sharing the naturalist's thrill of sudden discovery in the field. While Darwin could achieve great theoretical insight by wandering through virgin jungles, the modern biologist must be content to trace evolution through subtle variations in protein structure—his jungle, a forest of exotic equipment. Only the sea remains as unexplored and mysterious as it was in Darwin's time, its processes only slightly better understood. Now the scuba, the deep submersible and, most of all, the underwater habitat have opened the sea to intimate exploration, simultaneously creating a new breed of spellbound naturalists.

Recently I scuba-dived with SCORE program coordinator James Miller of the National Oceanic and Atmospheric Administration to see, first hand, the most active habitat of them all, the 8-foot by 16-foot Hydro-Lab. While support divers struggled to take the heavy iron "pot" of supplies to the current team of aquanauts, 60 feet below the choppy, windswept surface, Miller and I swam along the bright yellow lifeline stretching out of sight toward The Ledge.

We paused and stood in the first "talking station," an inverted acrylic hemisphere, about three feet in diameter, filled with air. Our voices rang metallic and hollow, and the surrounding stillness seemed to amplify the sound of breathing. Miller explained that the stations had originally been surrounded with metal bars to protect against sharks, but since none had ever bothered the divers here, the hemispheres now float like giant jellyfish, anchored by ropes. Divers returning from the daily excursions over The Ledge pause here to decompress and discuss the day's work.

Beneath the Hydro-Lab we took off our tanks and one by one entered the "trunk" that extends a couple of feet on either side of the lab floor. Internal air pressure restrains water at the lower lip of the trunk. Climbing out the top, I found myself standing in a dimly lit cylinder, partially carpeted. From the far end of the cylinder, light reflecting from the white, sandy ocean floor poured in through a four-foot acrylic window. Two air mattresses had been shoved to the left side of the carpet, beneath two bunks hanging from the wall. A bank of radio equipment covered the righthand wall, above a small table holding a coffee pot and some freeze-dried food. Wet gear—including a clothesline of dripping swimsuits—was carefully confined to the uncarpeted area around the trunk.

"It's like living in an underwater pup tent," aquanaut David Olsen said, describing his isolated refuge. The beauty of the arrangement is its very simplicity, he continued, facilitating a daily routine that minimizes the need for diving expertise. As water gurgled loudly at the base of the trunk he paused and became less rhapsodic, conceding that a week in the resonant steel chamber is also like "living in a running toilet."

The air felt warm and damp, and smelled of sweat. Minor ailments among the aquanauts have posed a problem from the start, as the close, damp quarters provide an ideal breeding ground for bacteria. Blood samples taken from scientists working in the habitat usually show markedly raised white corpuscle levels due to increased exposure to the bacteria. Not surprisingly, Walter Jaap was sniffling from a cold he had caught while living in the Hydro-Lab.

Air is pumped into the habitat through a tube running to a small boat that remains untended on the surface. If this connection should snap, back-up emergency air and power systems within Hydro-Lab itself could keep the divers alive until help arrived. Such system redundancy is particularly important considering that the SCORE project is pushing the state of the art for prolonged deep dives, using persons selected for their scientific ability rather than their diving expertise. So far only one major accident has occurred during

group of "coral-line" sponges that become the primary reef builders between 210 and 300 feet depth. The sponges were eventually assigned to a new taxonomic class by themselves, the Sclerospongiae. Eventually the reef was explored to a depth of over 900 feet, using the submersible Nekton Gamma. (One of the scientists involved, Judith C. Lang, describes the deep Jamaican reef in detail in the May-June, 1974, AMERICAN SCIENTIST.)

Reef biologists at Hydro-Lab hope to build on this pioneering work in two ways: by providing a more detailed look at individual plants and animals down to 250 feet than would have been possible inside a submersible, and by comparing the earlier finds to those in colder water. Though data gathered during the SCORE missions must still be analyzed, already some new insights into the developing picture of deep reef ecology are emerging.

Coral studies were carried out by aquanauts David Olson of the Bureau of Fisheries and Wildlife in the U.S. Virgin Islands, Walter Jaap of the Florida Department of Natural Resources and John Halas of the Harbor Branch Foundation. Abundance and distribution of the corals as a function of available light were measured, experiments to determine the amount of damage caused by various chemicals were carried out in a natural setting, and a little-known process by which corals of various species established a "pecking order" in a certain location was observed.

Philip Dustan of the Harbor Branch Foundation, who took part in the Jamaica submersible dives and was working in the Hydro-Lab support facility on shore, says the free-floating larvae of coral have distinctive chemical markers (surface antigens) that adult coral can detect as "friend or food." A larva can thus come to rest safely in a stand of "friendly" coral and take hold, or can be eaten if it drifts into unfriendly territory. By watching similar aggression patterns between adult coral, an order of dominance can be established for a given location, and Dustan says there is particular interest in seeing if the order changes as one moves from one area to another.

Another team studied the more than 300 species of algae, ranging from microscopic size to two meters long, that grow at various depths from shore to far down on The Ledge. Specially prepared light meters and a spectrometer allowed preparing the first correlation of population distribution to light intensity and available apectrum. The divers included Sylvia Earle of the Los Angeles Museum of Natural History Foundation, Thomas Hopkins of the University of West Florida, and Gerd Shriever of the University of Kiel, Federal Republic of Germany.

Earle says one of the biggest surprises to have been discovered at depths of around 250 feet is that green algae can live there at all, much less become the dominant species. The color they absorb best has already been almost completely filtered out by the water overhead. According to plant physiologist F.T. Haxo of the Scripps Institution of Oceanography, who cooperated with the mission by working in the surface laboratory, the secret of the algae's ability to survive at depth lies in a special set of extra pigments that absorb light in the limited wavelengths available and pass the energy along through electron excitation to reaction centers where photosynthesis takes place. Little is known about this adaptive mechanism, and Haxo is particularly interested in seeing whether the number of pigments feeding into a reaction center increases as available light gets dimmer, or whether some other adaptation takes place.

Not all of this mission was concerned with algae, however, and Hopkins's work

SCORE, when a diver went into convulsions near The Ledge. Unable to reinsert his mouthpiece through his clenched teeth, two other divers quickly carried the victim to a nearby Sub-Igloo—a spherical acrylic enclosure, filled with air, placed at the 90-foot level for just such emergencies. After nearly two and a half hours, the man recovered enough to be evacuated by the Johnson-Sea-Link. He later returned to work on another mission.

The aquanauts said they had not been bothered by some of the psychological problems that plagued earlier habitat dwellers. They had not felt so isolated, they said, because of contact with other divers who would come down each day for short periods of time. During earlier projects, aquanauts had sometimes developed what Miller calls an "us-versus-them" antagonism with support personal on the surface, with whom they communicated only by phone. Most of the time is taken up in working, and the divers said they had little opportunity for boredom. A hard day ends with a little light entertainment: Switching on the lights outside the large window to watch the active night feeding of tropical fish.

Each of the scientist-aquanauts expressed satisfaction with the unique opportunity for research provided by actually living in the sea. By spending long periods at depths of 250 feet, more detailed observations are possible. Though submersibles can, of course, go deeper, no equipment can yet replace a trained observer on the spot with hand equipment. This was particularly true for the third aquanaut I met on our dive, John Halas, who had to take close-up pictures of tiny organisms living on the surface of the deep reef.

After the dive I could better appreciate the way Sylvia Earle, a veteran of three habitats and half a dozen extended dives, describes her work beyond The Ledge: "You feel as though you're a hawk at the edge of a cliff, with blue infinity below you." The deeper you go the more blue everything appears, she says: "It's like walking in a full moon." Nothing shows its true color; blood, for example, is green and when you cut yourself "it's really spooky." I asked what sort of person she prefers to work with on a long dive. "One with a sense of humor and a cool head," she replied. "I'd rather have a topnotch scientist than an 'expert' diver"—as long as her partner can be counted on to help in a pinch.

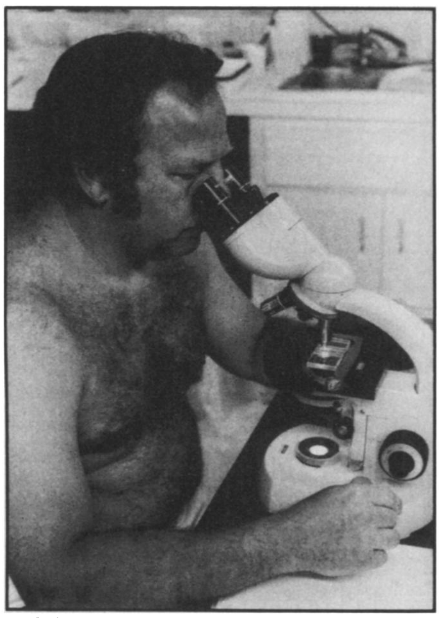
This mutual dependence produces an air of informality among SCORE workers far stronger than that evident around most scientific projects. "We have to watch out for each other," says graduate student Diane Grimm. "Diving is not an independent way to go. You have to interact with people; you have to be friendly." This feeling of unity became even more apparent that night as the group gathered for a party on board one of the surface tender boats, while waiting for the current team of aquanauts to undergo their 17-hour decompression. Professors, grad students and support divers were joined by actor Lloyd Bridges, who had also been diving to Hydro-Lab, filming a TV documentary. John Halas's wife Judy played the guitar as the group sang folk songs, ate fresh-caught fish and drank a hair-raising brew dubbed "science punch."

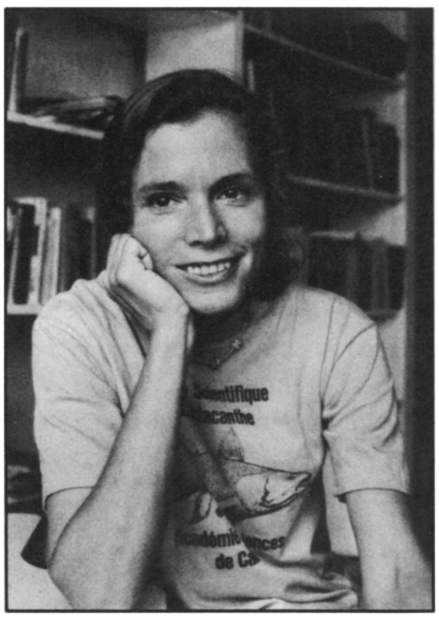
The next morning we found that a boat-load of ocean experts had overlooked the possibility that the fresh fish might be poisonous to eat, and at least two party-goers required medical treatment. A press conference was called for the just-surfaced aquanauts and when it was Halas's turn to speak, he promptly fainted. As a safety precaution, he was placed in a decompression chamber, but Miller explained that aquanauts often don't eat much during decompression because wastes cannot then be expelled from the completely sealed Hydro-Lab. Fainting from low blood sugar, he said, is not uncommon after a dive.

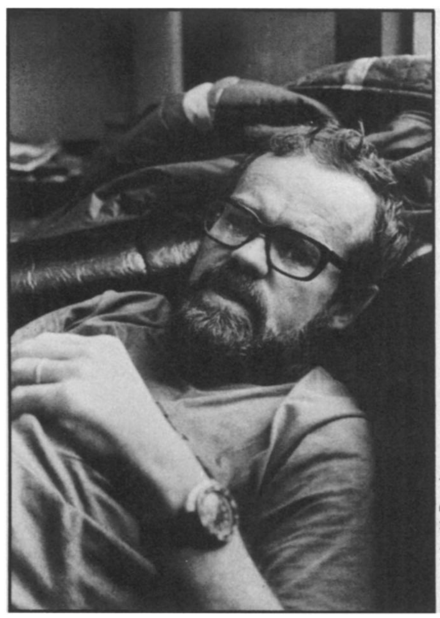
Despite the disruptions, Earle's team set out for their week in Hydro-Lab on schedule. The wondering naturalist of the sea was back where she wanted most to be—a hawk above a blue infinity.

—John H. Douglas

with the basket-star may have significant implications for environmental monitoring. These secretive animals hide during the daytime, curled up in small crevices, and come out at night to feed, waving their multitude of long arms from the top of a coral head or sponge. What makes them ideal as potential monitors of environmental damage, says Hopkins, is that they have such a regular feeding cycle and are so indiscriminate in what they eat—plankta, fish eggs or organic wastes. By establishing a baseline of their habits and body composition, he hopes to provide a tool for other scientists to use in assessing potential damage from pollution. If mercury, for example, were spilled in an area where the normal heavy metal content of brittle-stars is known, analysis of mercury uptake over a period of several days would give a reliable index of how fast the ele-


Philp examining diver's blood samples.


Sylvia Earle: 300 kinds of seaweed.


Thomas Hopkins: Starfish as monitors.

Photos: John H. Douglas

ment was being incorporated into the food chain.

The team concentrating on fish was actually culminating three years of effort using Hydro-Lab to measure the diversity, abundance and distribution of various species in the area. The team included ichthyologists C.L. Smith of the American Museum of Natural History and Robert Jones of the Harbor Branch Foundation, and fisheries biologist R.O. Parker of the National Marine Fisheries Service.

The group collected specimens, examined fish stomach contents to determine feeding habits, and observed hunting and breeding activities. Because of the previous work already accomplished, the team was able to concentrate their efforts on phenomena at the deepest extreme of their diving range, which included the particularly interesting "compensation depth" at which the rate of food production by plant photosynthesis equals and then falls below the rate of uptake by other organisms. Some new species of fish, previously unknown in the area, were also discovered. According to SCORE chief scientist Morgan Wells, the aquanauts once became so excited over a new find, they immediately sent it to the surface—preserved in a bottle of rum.

The final team made geological studies, concentrating on the transport of material in the reef-building process. The structure of the reef off Freeport consists of a gentle slope stretching out a mile and more from shore to a depth of about 90 feet at The Ledge. This escarpment drops almost vertically to below 400 feet where piled debris—called "talus"—tapers off gently at an incline about equal to the "angle of stability" of piled sand. Richard Slater of the University of Northern Colorado, Dennis Hubbard of the University of South Carolina and Jean Jaubert of the Laboratory of General Biology, Nice, France, participated in this mission.

The carbonate material of the living reef comes from coral, scleral sponges and calcareous algae, and as these die, the broken grains begin to migrate down the gentle surface slope toward The Ledge. Exactly what happens then is not yet understood, but as Wells describes it, a process of "cementation" takes place in which some of the material sticks to the growing outer edge of the reef, giving it the characteristic sharp drop-off. When samples of material chipped from The Ledge by the mission aquanauts have been carbon-dated, the rate and historical pattern of reef building should be better understood.

Apart from the plant and animal studies conducted by the aquanauts and their support teams on the surface, another set of experiments involved studying the divers themselves. Since their dives along The Ledge were pushing the state of the art, each diver was watched carefully to see if any physiological changes occurred. The decompression regimes were worked out with the cooperation of a Duke University team that simulated SCORE conditions in their hyperbaric chamber. One of the best ways of monitoring physiological effects of diving is through blood analysis, performed for SCORE by pharmacologist R.B. Philp of the University of West Ontario.

In the past, Philp says, decompression following such long dives has been accompanied by a marked decrease in blood platelet count. Electron microscope pictures show that platelets—which congregate as a sort of plug in a wound during normal clot formation—adhere to the surface of microscopic bubbles that form in the bloodstream during decompression. The decompression schedule being used on the SCORE aquanauts initially appeared to cause less platelet decrease, Philp says. According to SCORE medical officer David Youngblood of the Harbor Branch Foundation, Duke scientists have come up with an even better decompression schedule that may soon allow divers to work at depths encountered in drilling for offshore oil. The idea behind this "Vann-Hills" schedule, he says, is that it has divers spend relatively longer periods of time decompressing at larger depths, preventing initial formation of bubbles. Divers may soon be able to work for extended periods at depths as great as 1,000 feet.

Besides the new, scientifically interesting specific data gathered during SCORE, the greater understanding of the overall reef environment that is emerging from the continuous work at Hydro-Lab may have important practical consequences. "Probably the most important thing we can do," says Wells, "is to find out how much [man's interference] does damage to the reef." He adds ominously, "We are finding [tolerance] to be lower than we thought." Other spin-offs of the work are also immediately evident. Philp tells of being able to use the aquanauts to test the ability of a new drug to prevent platelet adherence—with results that may be important in the treatment of strokes and heart attacks.

Long obscured by more ambitious projects, such as Sealab and Tektite, Hydro-Lab has proven itself by providing scientists with varying backgrounds and diving skills a means of doing firsthand work on the ocean floor. The cost of maintaining the habitat, Wells says, is only as much as operating a 65-foot boat, and compared with the millions of dollars needed for the larger habitats, this, he says, "is a damned good deal." □