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Creatures in this under water forest could save your life one day

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DAUPHIN ISLAND, Ala. — It was 6 a.m. at the dock on a Tuesday in December, and the weather did not look promising. Fog hovered over the water, and the engine of the Research Vessel E.O. Wilson rumbled.

Our ship disappeared into the mist, and by 7:30 the crew, a team of biologists, chemists and microbiologists, reached its destination. The sun lounged on obsidian water, masking a secret world where land and sea swap places, and past, present and future collide.

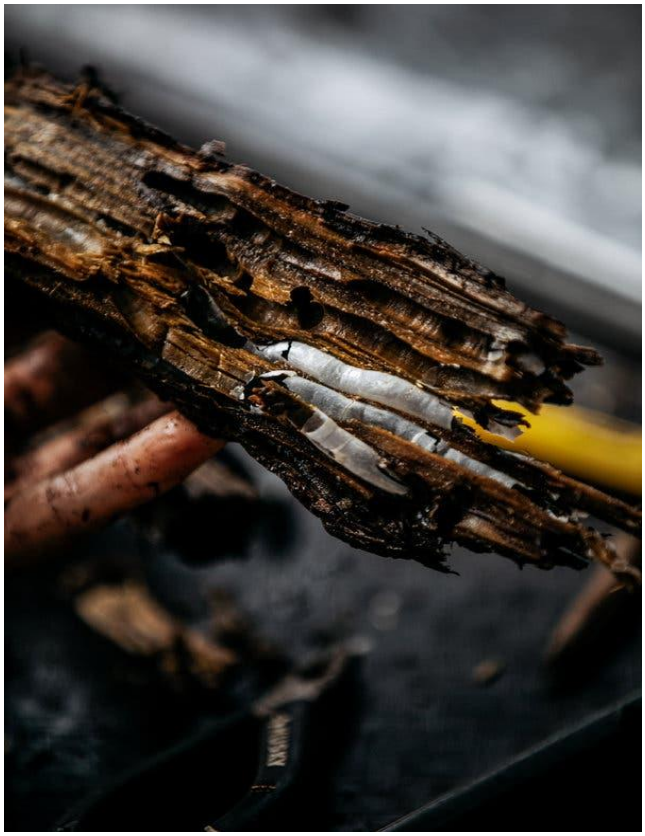
This is the underwater forest. Its unusual residents, shipworms and related marine organisms, could serve as incubators of unexpected medicines, churning out new lifesaving formulas and compounds that may not be found anywhere else on the planet. But first the group of scientists had to manage to dive 60 feet beneath the ocean's surface to recover their unusual subjects, a task made more challenging by three days of uncooperative weather.

"Underwater forest" is not a metaphor — this is a not a coral reef or a sea grass bed that resembles surface woodlands but bona fide trees with roots and leaves. For thousands of years, this cypress grove — about two football fields long and five feet wide — lay silent, preserved within an oxygen-less tomb of sand and sediment. Then came Ivan.

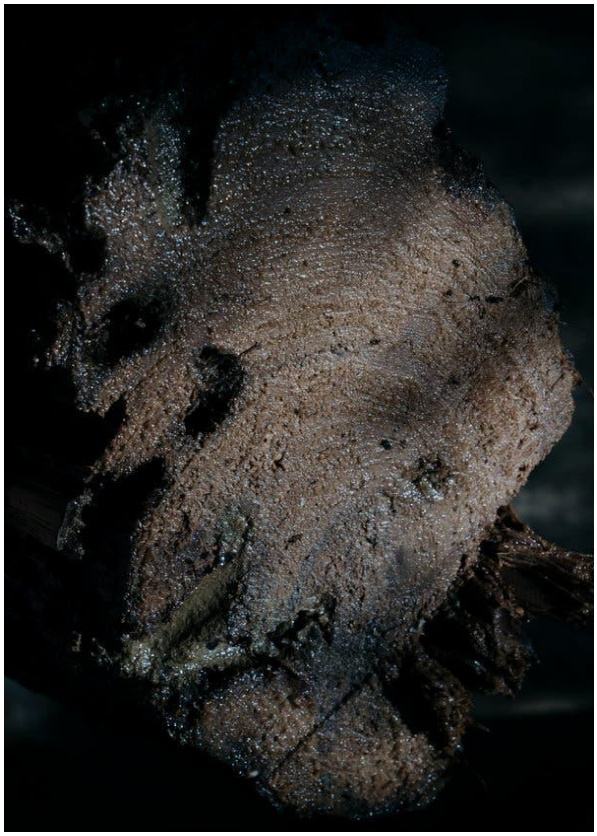
In 2004, the hurricane, category 5 before making landfall, ripped through the Gulf of Mexico, with winds up to 140 miles per hour kicking up 90-foot waves. The storm scooped up nearly 10 feet of sand from the seabed, awakening the sleeping forest beneath.

Now the forest whispers secrets of the gulf's past environment and climate, and hints at its future. Few have seen it, and those who have intentionally keep its precise location secret. But they entrusted this group of scientists, led by Dan Distel, a shipworm marine biologist and director of Northeastern's Ocean Genome Legacy Center, with the highly guarded coordinates for that day's expedition.

With a grant from the National Oceanographic and Atmospheric Administration, this group aboard the E.O. Wilson was the first to explore, document and study the shipworms and other marine xylophiles that moved into the forest when it emerged.



An ancient log, home to shipworms, which may help researchers discover new medicines.



Another log recovered from the underwater forest.

Shipworms, the scientists say, are critical for drug discovery. As aging populations increase worldwide and antibiotic resistance threatens public health, the medical field is seeking a new frontier that might yield novel drugs to treat conditions such as cancer and chronic pain, and to stem deadly infections. So they're turning to these aquatic wood-lovers and their symbiotic bacteria, which are great chemists.

Back on the boat, it was the team's last day for diving, and visibility at the underwater forest site was expected to be miserable. Time was running out on their search, and the forest, protected only by human trust, wouldn't last forever.

Their task was to examine the contents of this timber time capsule before another storm reburies it. But they also worry about someone working out the site's coordinates and harvesting its valuable lumber, or the prospect of other human activity, such as industrial projects, destroying it. The shipworms could also pick it apart faster than researchers can.

A front would arrive that afternoon, but during that narrow window on Tuesday morning, it was safe enough for the 46-foot ship to circle over the forest — "fifty percent less nauseating" than anticipated, said Brian Helmuth, a marine ecologist studying climate at Northeastern University. The team was ready to plunge into this odd oasis.

A place like no other

The forest was once a swamp about 100 miles inland. Its bald cypress trees, and their buttressed trunks as big as cars, supported a diversity of terrestrial life. But now it shelters grouper, red snapper, mantis shrimp, crabs, anemones and other sea dwellers. And for shipworms, it's an all-you-can-eat buffet.

"This is sort of like a wooden whale fall," Margo Haygood, a molecular biologist at the University of Utah, said before the trip; a whale fall is a dead whale that sinks to the seafloor. Life erupts around it.

Dr. Haygood has studied giant shipworms in mangroves in the Philippines with Dr. Distel. But they have never seen anything like this. No one has.

The sunken forest is larger, farther from shore and older than anything remotely like it. And as novel habitats and money for drug discovery dwindle, and with antibiotic resistance, new diseases, infections and age-related illnesses rising, the research team thinks it has everything to uncover new drugs.

Like wildflowers after a fire, diversity blooms as new habitats are established. In the early stages of settlement, when everything is still fighting for space, territory disputes kick up a lot of chemistry. And while sifting through it all, Dr. Haygood thinks there's a better chance for finding nontoxic new drugs that work well.

Shipworms appear to be good drugmakers, and while studying them elsewhere, the team has discovered compounds that are now making their way through the early stages of drug development.

Their pharmaceutical talent might be explained by bacteria living in their gills, which send enzymes to the gut to help shipworms break down wood. Somehow, this process also leaves the gut nearly sterile, suggesting antibiotics might be at play. And Dr. Haygood says that any compounds they find have already gone through millions of years of pre-screening in the bodies of evolving shipworms. This makes them likely to be less toxic to humans than drugs that are whipped up in a lab.

Each species, they have found, has a distinct and different set of bacterial partners, or symbionts. In their view, every unstudied species, every specimen, is potentially an unopened treasure chest of unimagined chemical combinations. And a site like the underwater forest might be concealing millions of unknown bacteria.

In 2005, a fisherman off Alabama's Gulf Coast wondered why he was catching so many fish at one spot. The seafloor in this area was mostly featureless sand. For decades, people have dumped junk in the water, from washing machines to World War II tanks and bombers, to attract fish. But no such structures had been dropped where he was pulling up such a catch; they'd have shown up on his fishfinder.

He called a local dive shop to check it out. The owner discovered trees on the seafloor and he knew the area was special. But why were the trees there?

Determined to find out, the diver eventually trusted the site with Ben Raines, a reporter then working for the website AL.com, who promised to find scientists to help. Mr. Raines, also an environmentalist and diving student, started publishing stories about the forest, and soon received a call from Kristine De Long, a paleoclimatologist at Louisiana State University.

The wood was too old for radiocarbon dating, but by analyzing tree rings, pollen grains and sand, she and a team of researchers discovered that it was two ice ages old.

Mr. Raines made a documentary, "The Underwater Forest," which brought the forest national media attention. Loggers and furniture makers, keen to harvest the trees for coffee tables or guitars, began sniffing around. Some offered small fortunes for the coordinates.

But few people, even longtime locals, know many details about it, like its specific location — or that it becomes less of a forest each day.

Diving by Braille

Eric Schmidt, a natural products chemist at the University of Utah, and Bailey Miller, a postdoctoral researcher, stood at the back ledge of the boat in diving gear: oxygen tanks on their backs, masks down, knives clipped to legs and rusty saw and sample bags attached to weighted belts.

The captain shouted — "Dive! Dive! Dive!" — and they disappeared into the water.

Within minutes they returned to the surface. "Pea soup," Dr. Miller said.

The team knew that visibility might be poor. Conditions are unpredictable, especially during flood season; this winter was rainy along Alabama's Gulf Coast. But funding is limited, and schedules rarely overlap. They couldn't wait.

Groaning, Dr. Schmidt rested on the deck. Dr. Helmuth and Francis Choi, a senior technician, prepared to dive next. "Just keep your hand on the transect tape," he cautioned, referring to the plastic ribbons laid along the seafloor as guides.

With footage captured during the dive, Dr. Helmuth and Mr. Choi hoped to build interactive 3-D maps of the habitat to better understand how its structure may provide protection in nooks and crannies from climate's extremes: Who is resilient? Where do animals seek refuge? By getting to know the communities that gather in habitats such as this, the team can take a closer look at climate change's likely effects in the Gulf and elsewhere.

But they returned empty-handed.

"It's nice down there, other than not being able to see anything," Dr. Helmuth said. "Chocolate milk."

Clouds accumulated, a breeze built, the sky darkened and the water vibrated.

Dr. Schmidt and Dr. Miller took another turn, but their dive was even worse.

“I had a surreal experience with a turtle,” Dr. Miller reported. He thought it was wood and knocked to check, and the two came face-to-face. “It’s kind of unsettling to run into something alive.”

The final dive was also a bust.

The sun returned. There was one remaining option: to scout the waters beneath a natural gas rig nearby, one of dozens visible from Dauphin Island’s shoreline.

If the underwater forest is a natural experiment, the gas rig offers an experimental control. Beneath the sea surface, the towering bases of the rig serve much like the eroding underwater stumps or any object tossed into these vacant waters: They are all “fish collectors,” Dr. Helmuth said, providing structure for sea life and people to enjoy.

The team wanted to see if deploying wooden blocks along the base in the future might address questions that can’t be asked at the underwater forest: Did the forest attract marine life that was already in the surrounding areas, similar to what is drawn to a gas rig? Or did it give rise to a unique ecosystem? How long does wood typically last underwater among wood-eaters under different environmental conditions?

The vessel, having reached the rig, idles on foamy water beneath its rigid steel beams, in a sticky, highway-scented mist. Three divers jumped in, disappeared and returned a few minutes later with good news: Visibility was perfect, and they captured great footage of the sea life to compare with footage from a previous dive in the forest.

Fog swallowed the rig as the boat left it behind. Then it swallowed the boat. Temperature dropped. The divers changed into dry clothes. Everyone rested.

The ship passed a lighthouse where shallow water washed over a beach. Buoys appeared, marking the ship channel in and out of Mobile. Farther off, shrimp boats floated between gas rigs.

If the rigs are a reminder of human activity, the forest is a reminder of what climate change can do, Dr. Helmuth said later. Since the Industrial Revolution, the change in environmental conditions produced by humans is comparable to what it took for natural processes to grow, kill and bury the forest over the course of 100,000 years.

The rolling weather signaled that time had run out for further examination of the forest. Luckily, during a sea-sickening dive on the prior Saturday, they still managed to collect six large buckets of logs, branches and roots.

A most unusual picnic

The day before Tuesday’s unsuccessful dive attempts, the team gathered around a picnic table beneath a beachy-pink building on stilts at Dauphin Island Sea Lab.

Dr. Miller dissected and examined wood recovered from the underwater forest.

A plastic tarp for a tablecloth, lunch trays for workstations. The researchers set out to categorize samples gathered during the more successful dive on Saturday. The wood was sorted based on how long each piece was estimated to have been exposed, from briefest to longest, in the hopes of understanding what types of creature settle on which substrate.

The wood was so pliable it could be picked apart with fingers, splinter by splinter. The scraps looked like pulled pork. Dr. Haygood welcomed today's guests of honor with gloves: shipworms, pholadidae and bryozoans, the oddballs that might bring drugs to the table.

Sailors named shipworms, which burrow into and devour wooden ships and dikes. But they are not worms; rather, they are elongated clams that grind into wood with microscopic teeth, and digest the wood with the help of symbiotic bacteria living in their cells.

Until naval engineers switched from wood to steel, shipworms were popular research subjects. Now they are "throwbacks," Dr. Haygood said. She hopes that the promise for drug discovery will attract more researchers to "this untapped treasure box."

Pholadidae, which resemble white grapes, are shipworms' younger cousins. Somewhere during their evolution, pholadidae lost the symbiotic bacteria in their cells, along with their ability to consume wood. But shipworm-associated bacteria that potentially contain additional pharmaceutical gold could hitchhike on their bodies.

Then there are the bryozoans, a phylum of animals all its own. Bryozoans attach to wood but don't eat it. Some colonies resemble gummy-ish lichens, but on closer inspection are woven squares. Each square, often smaller than the tip of a pin, is an individual animal. Its bacterial symbionts produce chemical defenses that protect the animal's soft body and larvae. Some of these toxins and other compounds could be helpful in treating Alzheimer's, cancer, H.I.V. or pain.

But even miniature crabs scampering from abandoned shipworm burrows or escaping Dr. Distel's petri dishes help to better understand how the community of organisms functions within the underwater forest: a log has something for everyone.

"In the ocean, something to attach to is very important," Dr. Distel says. "You don't think about that much in the terrestrial world. But if you want to not get washed away by currents, or if you want to be able to find other members of your species, it's important to have landmarks."

As the team picked out specimen after specimen, they carried them up to a makeshift lab usually used as a summer-camp classroom. They documented and processed as many samples as possible before returning to their home labs in Utah and Massachusetts.

Dr. Haygood scraped a smoothie-like mixture of freshly-ground shipworm, which also contained the bacteria from inside its body, and spread it in zigzagging lines into petri dishes and tubes filled with a jellylike medium. She hoped this would prompt the shipworm's bacteria to colonize the medium and start growing.

"It takes patience, imagination and empathy with the bacteria," she said.

A single specimen can generate dozens of strains of bacteria. Screenings are difficult, and take months. If a compound passes all the tests, presuming funding continues, they might reach the clinic in 15 to 20 years. Back at the lab on Tuesday, the day of the final dive, the divers had already showered and returned to the less daring work of science. Dr. Miller was picking apart more wood, while Mr. Choi finished a computer simulation of a large log. Dr. Distel was hunched over a microscope with tweezers, separating pholadidae. There was a whole log that had not been touched, and they neared the 200th page in a notebook for documenting specimens.

They had generated enough work to last a lifetime, or more. Frozen at ultracold temperatures, some bacteria can survive "probably longer than the human race," Dr. Distel said.

Months later, it seemed as though all the seasickness, scratched dives and buckets of splinters might have been worth the trouble.

"Before we visited this site, I had nightmares that we would not find much of interest at all," Dr. Distel wrote in an email. But from a single near-blind dive into only a fraction of the forest, they had found five species of wood-loving marine creatures that they had never examined before.

They don't know if these organisms conceal a miracle medicine. But they're always eager to hunt for more clues in places like the submerged forest.

"There's no such thing as an uninteresting shipworm," Dr. Haygood said.

Source: https://www.nytimes.com/2020/03/31/science/underwater-forest-shipworms.html