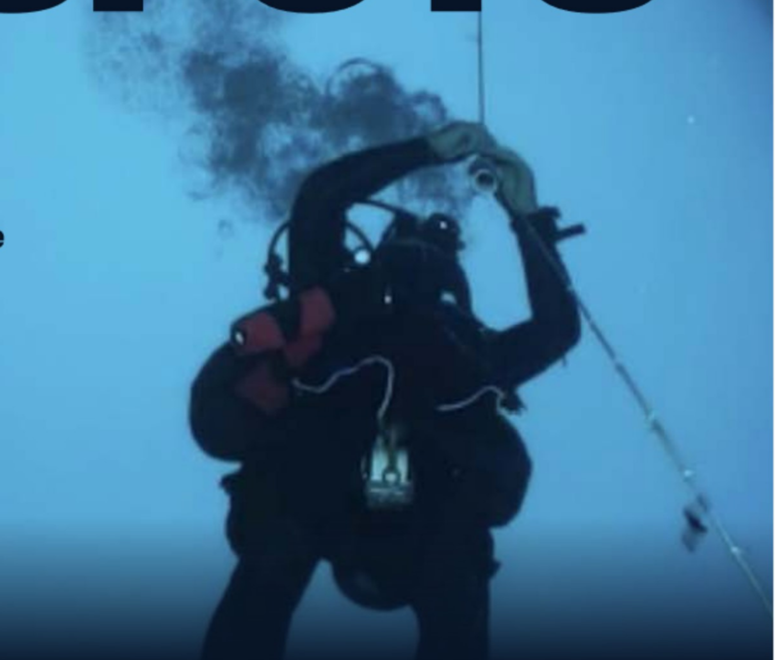
HOPE SPOTS HOT SPOTS

In deep, 'ecological hotspots' divers find endangered species, weird microbes, and hope for better understanding the Gulf of Mexico.



BY HAYLEY RUTGER

In August, world-famous oceanographer Dr. Sylvia Earle and her organization Mission Blue named a large swath of Florida's Gulf of Mexico Coast its newest "Hope Spot," a place with unique ocean ecosystem features worthy of preservation.

This Hope Spot, stretching from Apalachicola Bay to Ten Thousand Islands, raises awareness of the region's fascinating natural features. Perhaps the most mysterious of those features are "blue holes": underwater caves, springs and sinkholes that support diverse marine life.

Mote Marine Laboratory scientists have pioneered the scientific exploration of blue holes, and their extensive knowledge supported the new Hope Spot designation.

"A big blue salute to the champions in Florida who have gotten behind the Florida Gulf Coast Hope Spot," Earle said, noting that the region has "joined more than 100 places around the world where people such as you have stepped up and committed to making a difference."

Mote President & CEO Dr. Michael P. Crosby said: "Mote scientists' exploration of blue holes—one of the many projects we lead within the Hope Spot—may provide invaluable insight into the Gulf's unique ecosystem."

That's partly because blue holes are some of the "hotspots" of the Hope Spot.

"We call blue holes 'ecological hotpots' because they're really biologically diverse and chemically distinct compared with the areas around them," said Dr. Emily Hall, who leads Mote's Ocean Acidification Research Program and Chemical & Physical Ecology Program and serves as Primary Investigator for Mote's latest blue-hole study supported by a competitive grant from the National Oceanic and Atmospheric Administration's (NOAA's) Office of Ocean Exploration and Research. Project partners include Jim Culter, Mote's Benthic Ecology Program Manager and a pioneer of Gulf blue hole exploration, and scientists from Florida Atlantic University's Harbor Branch Oceanographic Institute (FAU), Georgia Institute of Technology and the U.S. Geological Survey (USGS).

In May and September 2019, the team undertook their most detailed blue hole investigations to-date, deploying divers and a "benthic lander"—a framework holding multiple scientific instruments collectively weighing more than 600 pounds—into one of their two project study sites: the offshore Amberjack (AJ) Hole, whose bottom extends deeper than 350 feet.

Here is what the team discovered inside one of the deepest, darkest—and coolest—places within the Gulf Hope Spot.

PHOTO BY: CURT BOWEN

SEEN A SAWFISH?

The public should report sawfish sightings, alive or dead, to NOAA at: **1-844-SAWFISH**

Top: One of two smalltooth sawfish discovered at the bottom of AJ Hole by Mote's team of trained, technical divers.

Sawfish surprise

From small tube worms to gigantic whale sharks, Mote scientists have documented diverse animals at blue holes—and their latest expedition made the list even more wild.

“Around the rims of blue holes we can see endangered and threatened species like sea turtles, and various species of sharks and other fishes, and the holes are important places for saltwater fishing,” Culter said. Those species feed on others found in greater abundance and diversity around blue hole rims: crustaceans, clams, worms, sponges, corals, algae and more.

About 30 feet below a blue hole's rim, visible life dwindles as dissolved oxygen drops and hydrogen sulfide compounds prevail (read: rotten egg smell). After a certain point, microscopic organisms rule the chilly, pitch-black, "alien" environment. Imagine, then, the surprise when Mote's blue-hole divers descended into AJ Hole in September 2019 and spotted an endangered species lying on the bottom.

“Two of our volunteer tech divers were searching for an instrument I had placed there in May, when they found two smalltooth sawfish,” Culter said, referring to the shark-related species known for its saw-like snout and listed as endangered largely because of fisheries bycatch and habitat loss. “Our divers got video, and when they got to the surface, they were crazy excited.”

The bad news: Both sawfish were dead. The good news: They appeared intact enough to be collected for research. Mote scientists quickly reported the discovery to NOAA and the Florida Fish and Wildlife Conservation Commission (FWC), the respective federal and state agencies overseeing the species. Special permits are required to interact with sawfish, alive or dead. At press time, one sawfish from AJ Hole has been successfully collected by divers working under a NOAA-issued, Endangered Species Act Section 10 permit. It was transferred to permitted FWC staff for a necropsy (animal autopsy). The sawfish was male, measuring an impressive 12 feet long.

Natural laboratories with extreme creatures

While marine animals thrive at the rims of blue holes, those that travel deep inside can't survive there long. Which living things do thrive in the low-oxygen, low pH waters near the bottom?

Scientists want to know so they can better understand how the Gulf ecosystem operates today, and make better ocean predictions for tomorrow. Globally, oceans are decreasing in average pH and oxygen levels due to human activity—not becoming as extreme as blue holes, but inching a bit closer to them in ways that have real ecological consequences.

“Blue holes are ‘natural laboratories’ that can help us understand changes in our environment, especially in light of decreasing pH, or ocean acidification, which is a component of climate change,” Hall said.

UNDERWATER PHOTOS BY: CURT BOWEN

To explore AJ Hole's natural lab in new detail, Hall and Culter's team collected some 17 water samples in September from just outside AJ Hole down to the bottom, and four sediment cores at the bottom, allowing the team to measure nutrients and carbon-based compounds. The benthic lander—provided by Dr. Martial Taillefert, Professor in the School of Earth and Atmospheric Sciences at Georgia Tech, and operated in collaboration with Dr. Jordon Beckler, Assistant Research Professor and Director of the Geochemistry and Geochemical Sensing Lab at FAU Harbor Branch Oceanographic Institute—collected data and samples for longer periods than divers can, right where the bottom water meets the sediment.

PHOTO BY: AJ GONZALEZ

Above: A technical diver passes by the benthic lander at the bottom of AJ Hole, close to 350 feet deep.

Right: Dr. Nastassia Patin of Georgia Tech holds a microbial sample from AJ Hole.

Getting it down there was an adventure. "Even though the lander is about 5 feet across and blue hole openings can be 100 feet across, it's really hard to get something like this down there and anchored in the right place without trained divers guiding it, especially when you're 33 miles offshore and the boat is really rocking in rough seas," Hall said. "Also, if the lander wasn't anchored properly at the bottom, it could slide down the side of the debris pile." That actually happened during May's expedition, but the lander still collected samples and data after its mini "ski trip." In September, the lander was secured successfully near the center of the debris pile.

Water samples collected by divers and the lander yielded microscopic life (microbes) whose DNA was extracted, processed to isolate specific marker genes, and analyzed by Dr. Nastassia Patin, Postdoctoral Researcher with Prof. Frank Stewart (project co-PI) at Georgia Tech.

"One cool thing we found is that, in the bottom layer of water around 350 feet down, 40 percent of the microbial community was represented by Woesearchaeota, which is generally a very small minority—like 1-2 percent, if it's present at all—in most marine communities." Woesearchaeota is a type of archaea, belonging to a different domain of life than bacteria. Finding such a high prevalence of it is unprecedented.

Overall, the microbes in AJ Hole were layered, with different genetic varieties at different relative abundances among the top, middle and bottom layers of water. Patin noted: "The next step is to sequence the full genomes of the microbes we are finding, so we have a better idea of what these organisms are like and what they can do, biochemically."

Even before that step is completed, it's clear that microbes play important roles in shaping the unique environment of AJ Hole, and likely other blue holes. Now, the current research effort is building a fuller picture of how these holes operate biologically, chemically and physically, and why that matters.

Underneath it all

This year's expeditions showed that blue holes are busy—not only with life, but also with carbon and nutrient cycles that underpin life.

"The team found that AJ Hole's water and sediment have huge amounts of dissolved inorganic carbon, which can support some kinds of life—including microbes that can put that carbon back into the environment in a form that other organisms can access." Hall said. This process is important in global carbon cycles, which must be understood to make accurate climate change projections. "The team found that AJ Hole is a place where a lot of carbon is being put back into the environment. We have to pay attention to this. The Gulf has many blue holes, and if the same thing is happening in all of them, then that's a lot of carbon contributing to the Gulf's carbon budget."

FAU and Georgia Tech scientists investigated nutrient dynamics and other chemical processes—including the sulphur and metal compounds microbes "breathe" in the absence of oxygen—in sediments and the bottom-water interface in AJ Hole, using sophisticated instruments on the benthic lander.

"The most interesting thing is that we saw nutrient flux from the bottom sediment into the water; the fact that we were able to document that with both cores and the benthic lander is huge," said FAU's Beckler. Based on preliminary analyses of 2019 expedition data, he said: "We think nutrients are coming up from the blue hole, fueling primary production above the hole, and in turn, a whole cascade of larger organisms—but some carbon/nutrients ultimately cycle back to the sediments as detritus, fueling additional fluxes and restarting the positive feedback cycle."

To complement the nutrient work of Beckler and Taillefert, Hall is currently analyzing data on how far nutrients drift outside AJ Hole. As Beckler noted, project data suggest that nutrients reach the rim and support primary production by microscopic algae

Above:
Jim Culter of Mote holds a container he used to collect a sediment core from AJ Hole.

Middle and bottom:
Dr. Jordon Beckler and Andrew Stancil of FAU process sediment from AJ Hole to investigate nutrients and carbon.

(phytoplankton), plant-like organisms that, in turn, feed other species. Phytoplankton also include harmful species, such as the toxin-producing Florida red tide algae (*Karenia brevis*) that forms blooms offshore in the Gulf. The team found no *K. brevis* in the offshore AJ hole, but they found a sister species called *Karenia asterichroma*, which produces brevetoxins like *K. brevis*.

How do blue holes get so fertile to begin with? "We think that these areas with seafloor 'roughness'—whether it be a blue hole or just a generic ledge—offer organisms not just shelter to hide, but also serve to physically trap organic carbon and nutrient detritus," Beckler said. "Upon their degradation in sediments and release of bioavailable nutrients to kickstart the positive feedback cycle, this geochemistry now fuels an 'ecological engine' that promotes life, beyond just aggregating it. Only through interdisciplinary collaborations like this can we uncover the true mechanisms linking biology to geochemistry."

Above: From left: Jim Culter of Mote, Nastassia Patin of Georgia Tech, and Dr. Emily Hall of Mote get ready for the September 2019 deployment of the benthic lander, shown here, into a blue hole.

Hints of groundwater connections

Some blue holes seem connected to other cavities in Florida's porous, limestone bedrock, and the groundwater they contain. Such connections, if confirmed in multiple blue holes, should be investigated as possible "shortcuts" for saltwater intrusion into the Floridan Aquifer and its drinking water, or conversely, for fresh water carrying land-based chemicals—including nutrients—offshore.

USGS scientists have already amassed evidence that groundwater and ocean water mix along west Florida—and USGS Research Geologist Dr. Christopher G. Smith is expanding that understanding further to include sites further offshore, as a partner in the 2019 AJ Hole expeditions.

This year, Smith and partners found that water sampled inside AJ Hole contained markers of groundwater—naturally occurring isotopes of radium and radon suggesting water moved from the ground into the hole. While this doesn't necessarily mean AJ Hole connects all the way back to the Floridan Aquifer, it reinforces that blue holes aren't isolated from the groundwater, and the extent of their connections must be further studied. ■

FOLLOW ALONG

Keep up with the blue hole science team and watch videos related to this story at Hall's blog on Mote's website: **Deep Thoughts: Exploring Blue Holes**, at:

MOTE.ORG/DEEPTHOUGHTS