Researchers investigate the ocean's deep biosphere

April 24 2017, by Michelle Boston

Credit: Janice Kun for USC Dornsife Magazine

Bundled in layers of blankets for warmth, Laura Zinke settled in for a two-hour ride to the bottom of the ocean. The temperature dipped significantly once she and her colleagues passed the depth still touched by sunlight, and it would continue to drop as an engineer maneuvered the

Alvin submersible research vessel deeper and deeper toward the seafloor. Through a small porthole, Zinke saw fluorescent creatures flit by.

"Looking out the window was like staring into the night sky, but the stars are moving," said Zinke, who is working toward her Ph.D. in marine biology and biological oceanography at USC Dornsife.

Her descent to the deep biosphere—a habitat comprising the ocean floor made up of sediment teeming with microbes and the underlying rocky subseafloor—was part of a scientific research cruise to the Dorado Outcrop. The rocky ridge lies 125 miles off the west coast of Costa Rica, approximately two miles below the ocean's surface. Her mission was to collect water and sediment samples to take back for testing and to gather data on the microbes living around the site.

As a research assistant affiliated with the Center for Dark Energy Biosphere Investigations (C-DEBI), headquartered at USC Dornsife, Zinke's research will help build scientists' understanding of the deep biosphere.

"When we think about the ocean, most people think about the surface of the ocean and the coastal environments close to the shores," said Jan Amend, director of C-DEBI and professor of earth sciences and biological sciences. "But most of the ocean is not close to the coasts, and most of it is not at the surface."

The ocean covers roughly 70 percent of the Earth, reaching down an average of two miles. At the bottom, the sea floor measures another six miles or more deep at its thickest points, making it one of the largest habitats on Earth—and one of the most difficult to explore.

"It's a large operation akin to a NASA mission, really," Amend said.

And like NASA, C-DEBI has, from its founding in 2010, sought to expand humanity's reach into this unexplored frontier. The center's researchers have made it their mission to understand this ecosystem, from the muddy sediment to the microorganisms that call the subseafloor their home.

"We want to find out what kind of organisms inhabit those spaces. How are they similar or different to organisms that we know about from the open ocean or the surface world? How many are there? How are they distributed? How diverse are these communities?" Amend said.

Because the subseafloor ecosystem is so large, it almost certainly affects the world's climate, according to Julie Huber, C-DEBI associate director and an associate scientist at the Marine Biological Laboratory in Massachusetts.

"We're trying to understand the role these microbes play in some of the most basic geochemical processes and how they affect the environment of our planet," she said.

C-DEBI is a National Science Foundation–funded Science and Technology Center led by 10 scientists, including Amend and Huber, representing eight institutions across the United States. It's also the flagship hub for scientists who study the deep biosphere. The center offers grants and fellowships, as well as a robust "K to gray" education program that fosters STEM education for professionals and novices alike.

Since its launch, research produced by C-DEBI scientists has resulted in groundbreaking discoveries that lay the foundation for understanding life below the ocean.

A recent study published by Doug LaRowe, assistant professor

(research) of earth sciences at USC Dornsife, characterized marine sediments on a global scale for the first time. His work produced an estimate of the total amount of marine sediment in the oceans, the average thickness of the sediment blanket, an estimate of how much water is trapped in those sediments, and the temperature of the sediments and water at the ocean floor.

These numbers are incredibly helpful for researchers because they provide foundational scientific information that helps establish basic understandings of the deep biosphere, explained Amend, who collaborated with LaRowe. For instance, they found that the amount of water estimated to be trapped in marine sediments is almost three times as much as that in all glaciers and ice sheets across the continents.

"Marine sediments turn out to be the second largest reservoir of water after the ocean," Amend said. "They're a distant second—about five percent of the amount of ocean water—but now we can start asking questions about the exchange of water from the ocean to the sediments as well as the exchange of mass, nutrients, energy, organisms. It's huge for us scientists."

In another important study, C-DEBI researcher Steve D'Hondt of the University of Rhode Island discredited a long-held understanding of marine sediments. Scientists believed that ocean sediments contain no measurable oxygen below a few centimeters. Looking at samples from a wide range of locations, D'Hondt found that oxygen was, in fact, still measurable all the way to the rocky basement in some locations, though not all.

That's important because it means the organisms living in those sediments may be oxygen users. "The type of metabolism they perform is different than what we used to think," Amend said. "That was a really, really big find."

Looking ahead, Amend said that C-DEBI researchers will focus their work on understanding the microbial life of the deep biosphere.

These steps are critical for scientific discovery, but also for another reason, said Huber.

"It's the type of science that captures people's imaginations and that is so important in training the next generation of scientists." Those like Zinke.

"Before C-DEBI there wasn't a central body saying that the deep biosphere is important, and we need to go forth and study it," Zinke said. "But we're looking at the really basic science questions that mean a lot in terms of how life evolves, and how ocean chemistry affects our world.

"It's been really fantastic getting to be part of this research structure."

Provided by University of Southern California