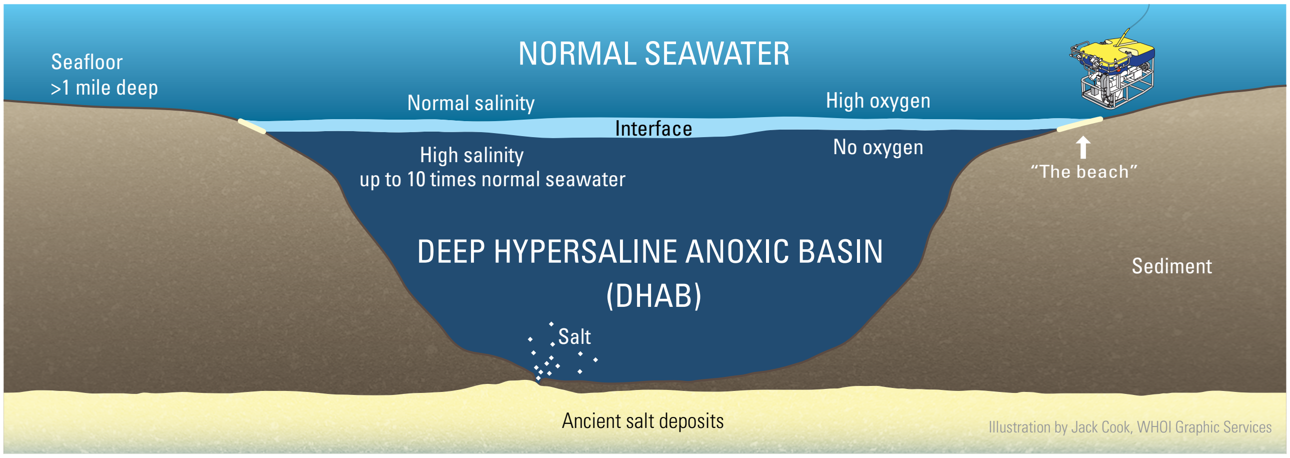
Can Animals Live Without Oxygen?

OR IS IT AN INVASION OF 'BODY SNATCHERS'?

by Kate Madin



Deep Hypersaline Anoxic Basins are among the most extreme environments on Earth. They form when salt from long-buried deposits dissolves into the ocean. The resulting extra-salty, ultradense water does not mix with normal, less dense, oxygenated seawater above it and gets trapped in seafloor valleys. The remotely operated vehicle *Jason* collected samples from "the beach" in the interface zone between the two types of water.

In 2010, a research team garnered headlines when it published evidence of finding the first animals living in oxygen-free conditions at the bottom of the sea. But a new study led by Woods Hole Oceanographic Institution (WHOI) scientists proposes an alternative scenario: The seemingly alive multicellular organisms, or metazoans, seen by the earlier team may have been cadavers inhabited by "body snatchers." Bacteria capable of living in anoxic conditions, they say, gave the appearance that the dead animals were alive.

WHOI geobiologists Joan Bernhard and Virginia Edgcomb led an expedition in 2011 that returned to the site of the initial findings: a deep hypersaline anoxic basin (or DHAB) two miles below the surface of the Mediterranean Sea.

DHABs are curious phenomena. They exist in depressions on the seafloor, where long-buried salt deposits become exposed to seawater and dissolve into the sea. The resulting hypersaline water is extremely dense and remains separated, like oil and water, from surrounding normal seawater. It forms "lakes" on the seafloor, tens to hundreds of meters deep, that are extremely salty and devoid of oxygen.

"We have known for a long time that some metazoans inhabit extreme anoxic habitats on a periodic or even semi-permanent basis," Bernhard said. "But scientists have thought that metazoans' high-energy activities, such as reproduction, would require oxygen. If these animals spend their whole lives and reproduce in a zero-oxygen environment, we would have to

WHOI scientists Joan Bernhard (left) and Virginia Edgcomb observe core sampling devices loaded onto the front basket of the deep-sea vehicle *Jason*. Using *Jason*'s manipulator arms, pilots push plastic cylinders (right) into the seafloor to collect sediment samples at the edge of the brine pool, which scientists call "the beach." Scientists examine the samples for anything living within them.

reconsider our concepts of animal metabolism. It was important to revisit the DHABs to confirm and understand those previous remarkable findings."

The original research team that first reported metazoan specimens from DHAB sediments in 2010 conducted experiments with fluorescent tags, which are taken up only by metabolically active organisms. The experiments indicated that the animals had been alive when they were collected. In addition, a few specimens appeared to have reproductive structures called oocytes (or eggs), indicating that the organisms were reproducing.

Intrigued by these findings, Bernhard and Edgcomb returned to the DHABs, using WHOI's remotely operated vehicle *Jason* to collect samples. The highly dense, saline, chemical-laden and oxygen-depleted water in the DHAB brine pools was too dense for *Jason* to fully penetrate. But the team was able to sample sediments in the "interface zone," the transition zone between normal seawater above and more concentrated saline and anoxic water in the DHAB below.

The WHOI-led team used a wide range of techniques to examine the collected metazoan samples. (These included incubation with a marker of living tissue, ribosomal RNA sequencing to identify species, epifluorescence imagery, differential interference and phase contrast imagery, and ultrastructural examination of individual specimens, to name a few.)

The team's results provided evidence that some metazoans were alive in the upper level of the interface zone. But in the lower interface, where there is almost no oxygen, the metazoans were degraded, often down to only their outer coverings.

"We found no evidence that these metazoans were living or reproducing in the deepest part of the interface," Bernhard said.

"It is intriguing to think that some metazoan species found in normal marine conditions possibly could adapt to hypersaline, hyperdense, hyperchemical brine pools, but it is unlikely," Bernhard said. "One alternative scenario is that remnant metazoa bodies were inhabited by living anaerobic bacteria and/or archaea"—which the team colloquially called "body snatchers."

"That earlier group's 2010 paper came out with such a splash, but it may be premature to rewrite the basic biology textbooks on metazoa," Bernhard said. "The contrasting findings by different research groups should stimulate interest and more research dedicated to understanding the curious physiologies of metazoans in DHABs."

The research was supported by the National Science Foundation. Results were published December 2015 in BMC Biology *by Joan M. Bernhard, Colin R. Morrison (University of Nevada Reno), Ellen Pape (Ghent University), David J. Beaudoin (WHOI), M. Antonio Todaro (University of Modena & Reggio Emilia), Maria G. Pachiadaki (WHOI), Konstantinos Ar Kormas (University of Thessaly), and Virginia P. Edgcomb.*

The Bottom of the Ocean On Top of Your Coffee Table

Here's a way to journey to the seafloor without leaving your living room or classroom. Five deep-sea scientists have created a comprehensive, lavishly illustrated book that transports readers to Earth's last frontier—where volcanoes, boiling hot springs, undersea mountain chains, bizarre terrains, and exotic life forms rival science fiction.

Discovering the Deep: A Photographic Atlas of the Sea-Floor and Ocean Crust was written by WHOI marine geologist Daniel Fornari and WHOI biologist Timothy Shank and their colleagues Jeff Karson (Syracuse University), Deborah Kelley (University of Washington), and Michael Perfit (University of Florida).

Ten years in the making, the book contains more than 500 full-color images and provides a history of seafloor exploration and the vehicles and technologies used. It describes the biogeochemical processes involved in creating myriad seafloor environments and sustaining extraordinary communities of life that thrive in dark, typically toxic, high-pressure habitats.

Published in 2015 by Cambridge University Press, *Discovering the Deep* received a PROSE Award from the Association of American Publishers, which annually recognizes the best in professional and scholarly publishing. For more information, see http://discoveringthedeep.com/.

—Erika Fitzpatrick