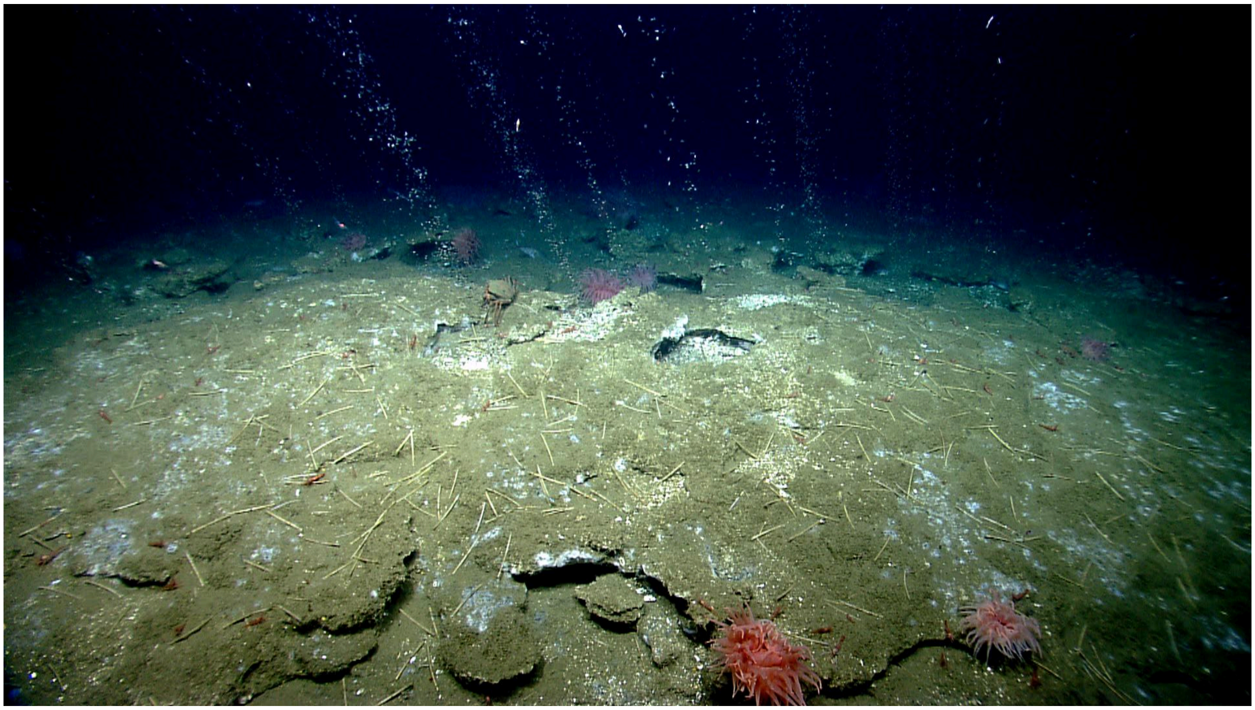
Title: Downstream Impacts

Case Study Methane Sensor

Summary sentence: An interdisciplinary team based at the Woods Hole Oceanographic Institution developed and field-tested a novel, in situ *methane sensor for deep-sea exploration that is smaller, more sensitive, and faster than existing sensors. Tests in the Gulf of California demonstrated that the sensor was successful in detecting methane.*



Bubble_streams_NOAA_Ocean_Exploration_2013 ROV Shakedown and Field Trials in th…

Methane seeps through the seafloor and can be detected with underwater sensors like the one developed for this project. Image courtesy of NOAA Ocean Exploration 2013 ROV Shakedown and Field Trials in the U.S. Atlantic Canyons.

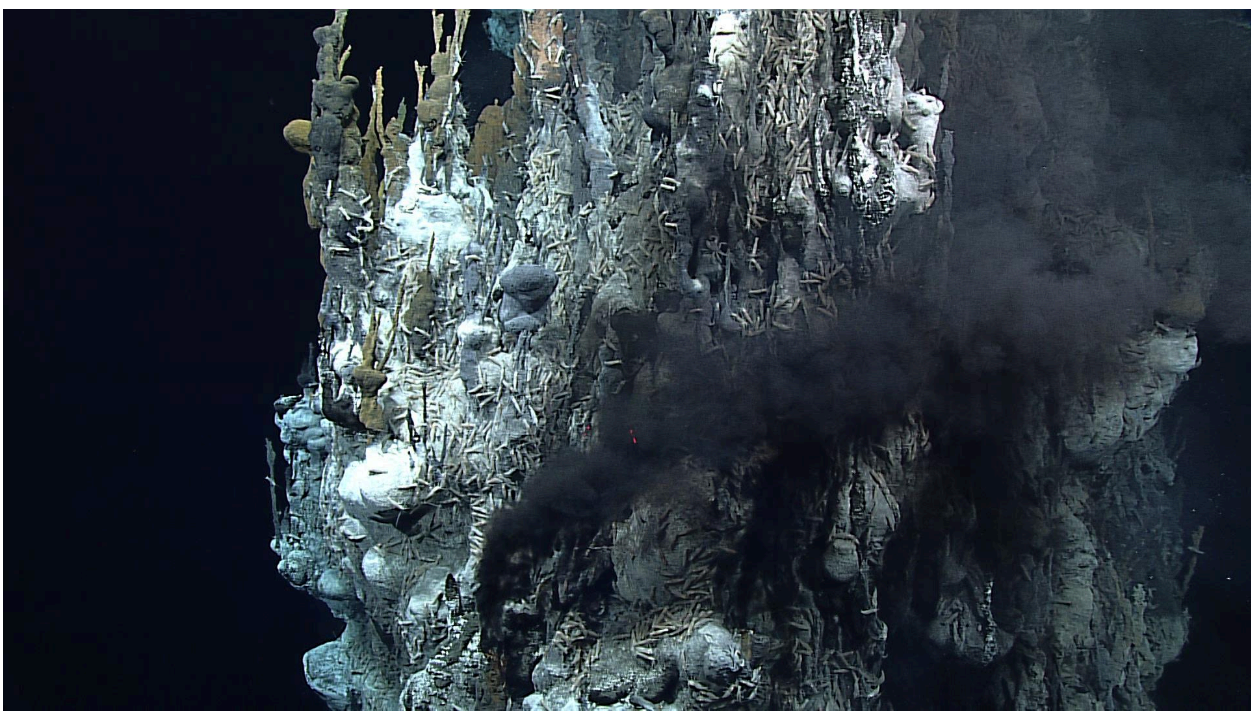
Measuring Gas in the Ocean

Beneath the ocean surface, liquid appears to rule the seascape. Organisms are highly influenced by the water pressing down on them, to the extent that their bodies are built to thrive even under extreme pressure, cold, and darkness. Studying the seafloor can reveal pockets of another state of matter, gas, in unexpected places.

Methane gas leaks from crevices in either steady or intermittent plumes and supports chemosynthetic organisms, or creatures that create energy from chemicals. Dissolved oxygen persists near the seafloor. Across the ocean floor and throughout the water column, gas plays a major role in sustaining life.

Though scientists recognize the importance of gasses at the bottom of the ocean (in habitat creation, climate regulation, and more), detecting gasses at a wide range of concentrations can be challenging. In order to fully understand the scope of biogeochemical processes and how gasses contribute to these cycles in the ocean, gas-detecting instruments need to be able to measure very small concentrations. In the past, this has required the development of large, costly instruments that require physical samples and associated analysis to occur after instrument recovery.

As the future of ocean science and exploration moves toward incorporating *in situ* testing (i.e., testing at the site where the sample is taken) that allows more timely information-gathering and the ability to guide sampling in real-time, there is a growing need for low-cost, highly sensitive, smaller instruments that can be attached to autonomously operated vehicles.

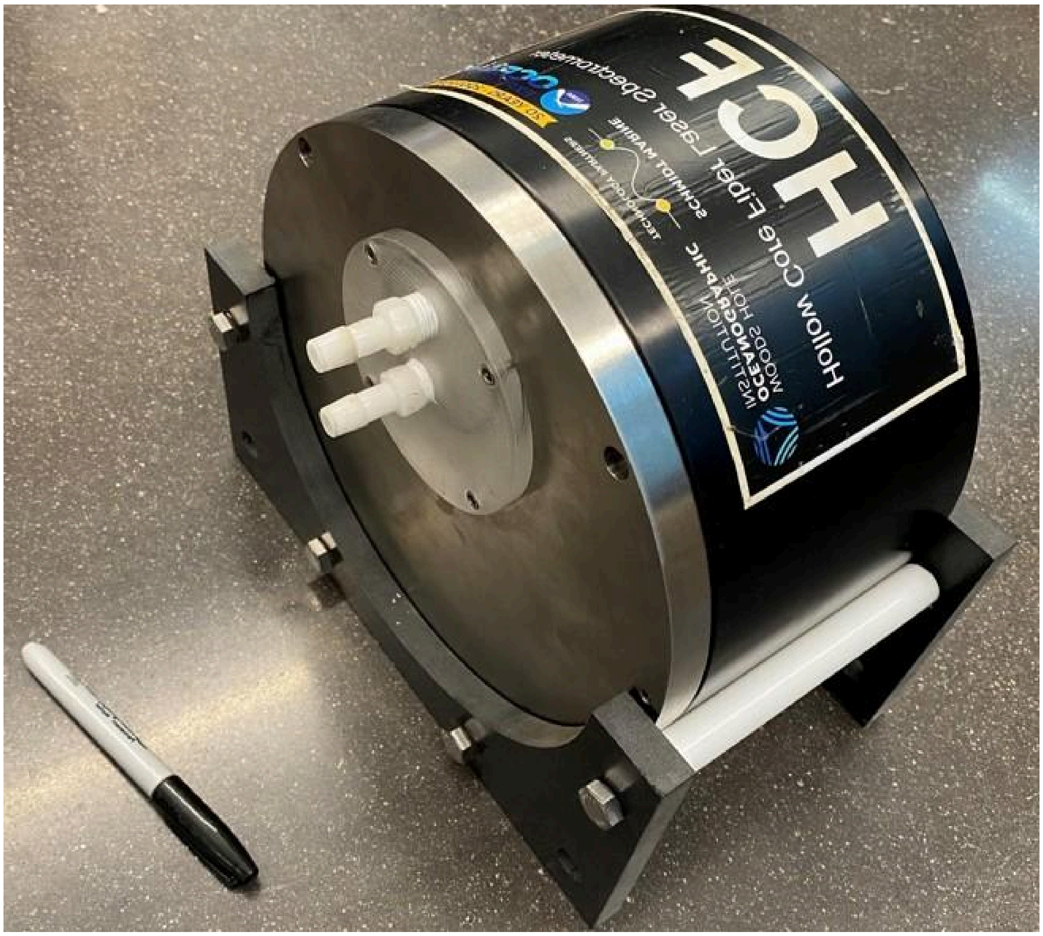


Black_smoke_NOAA_OE_2016 Deepwater Exploration of the Marianas.jpg

Underwater sensors can detect chemicals released at hydrothermal vents. Image courtesy of NOAA Ocean Exploration 2016 Deepwater Exploration of the Marianas.

Finding Methane in the Deep Ocean

An interdisciplinary team of biologists, geologists, and engineers from the Woods Hole Oceanographic Institution addressed this need by developing and testing a novel *in situ* methane sensor. The team designed a sensor using a hollow core optical fiber, a technique that drastically reduces the amount of gas needed for a measurement while still maintaining high sensitivity to gas concentrations.



HCF.jpg

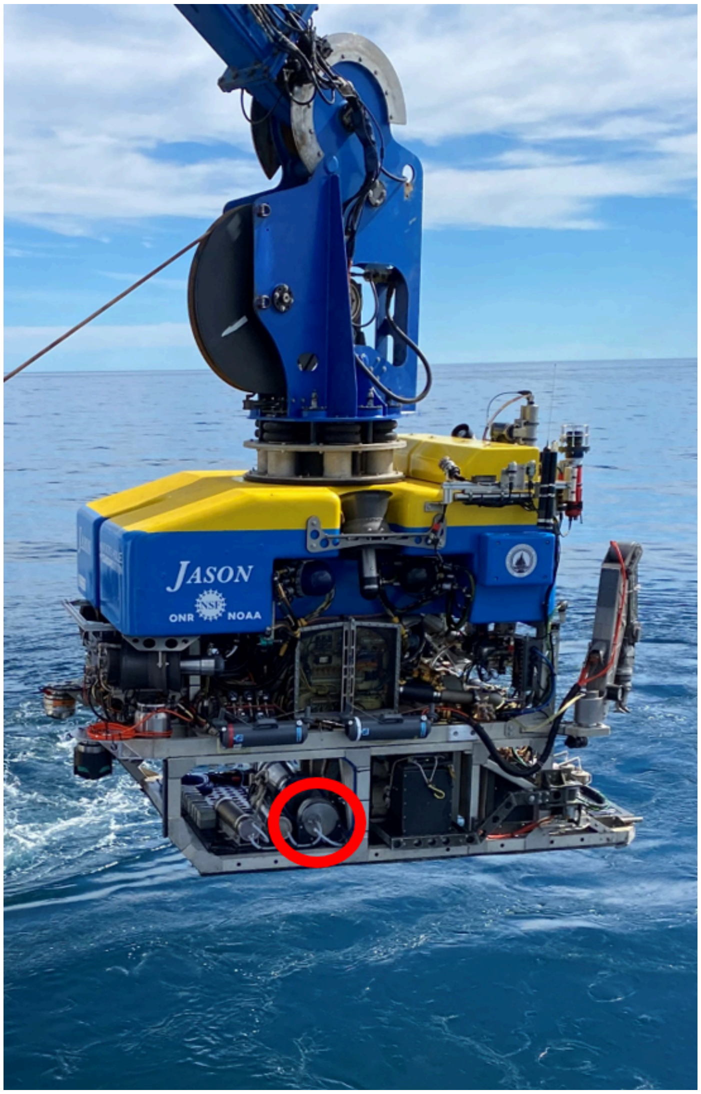
The Hollow Core Fiber Laser Spectrometer developed for this project and designed to take in situ *measurements of carbon dioxide and methane. A marker is shown for scale. Image courtesy of Woods Hole Oceanographic Institution.*

During field tests in the Gulf of California, the team secured the instrument in separate trials to an autonomous underwater vehicle (AUV), a conductivity, temperature, and depth (CTD) rosette, and a remotely operated vehicle (ROV). They then evaluated their instrument's methane-sensing capabilities by taking measurements at a hydrothermal vent outlet, the base of a collection of tube worms, and other biological and geological sites.

The team found that their sensor detected trace concentrations of methane as low as 5 parts per million and functioned at depths of up to 2,000 meters (6,562 feet). The instrument was able to track methane signals, which enabled the team to determine that concentrations of the gas increased significantly when approaching vent sites. With the methane sensor attached to either an AUV or ROV, the team detected and mapped methane where bubble activity was low and tracked plumes away from a gas source. Using the sensor coupled with a CTD, the scientists also created continuous methane depth profiles near vent sites.

By implementing a high-precision methane sensor into existing underwater technology, the project team was able to make chemical maps, measure black smoker vents and diffuse flows, and assess methane concentrations while keeping costs reasonable. The sensor is also smaller, more sensitive, and faster than existing standard methane sensors on the market.

Since field testing the device, the project team has been invited to join more ocean exploration expeditions to further develop their technology. In the future, the team expects to advance to commercializing the sensor, which will provide other groups and scientists the opportunity to use their technology worldwide.



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The Hollow Core Fiber Laser Spectrometer, circled here in red, is deployed on remotely operated vehicle Jason. *Image courtesy of Woods Hole Oceanographic Institution.*

Normal text