Deep-sea corals flourish in the dark depths of the Gulf of Mexico, providing foundations that attract lush communities of other animals, including brittle stars, anemones, crabs, and fish. This diversity of life on the seafloor may be out of sight, but it is squarely on the minds of scientists seeking to determine the short- and long-term ecological impacts of the Deepwater Horizon oil spill.

Life and Death in the Deep

Does the spill pose risks to seafloor communities?

"In the field of observation, chance favors only the prepared mind."
—Louis Pasteur

It was an experiment they hoped would never happen. But when it did, they were ready to respond.

In 2008, a multi-institutional team of researchers had launched a long-term study to explore the lush but little-known communities of corals, anemones, crabs, worms, fish, and other organisms that thrive on the seafloor in the Gulf of Mexico. The goal of the research team, led by Pennsylvania State University biologist Chuck Fisher, was to search for rocky seafloor areas, shipwrecks, oil rigs, and other hard foundations where these deep-sea oases of life develop and then examine the diversity of animals in them. But there was another, perhaps unstated, purpose that was always in the back of team members' minds.

"I'm not sure if it was ever written large," said Chris German, a geochemist at Woods Hole Oceanographic Institution (WHOI), "but pretty much (we) were funded to understand what the unperturbed environment would look like, in preparation for that terrible day that might come one day, where there was an accident, and you wanted to say, 'Well, what was the impact?'"

That terrible day occurred on April 20, 2010, when the Deepwater Horizon oil rig exploded, leading to the largest oil spill in United States history. Over the course of the spill, some 4.9 million gallons of oil and 1.8 million gallons of dispersants ended up in the Gulf.

Just months before, German, Fisher, and WHOI biologist Tim Shank had visited deep-sea ecosystems in the northern Gulf. Shank said that soon after the explosion, "federal officials began calling to say, 'You've been out there recently. You have the baseline observations for what the corals, and the animals living with them, and the environments were like prior to the spill. We want your knowledge. In fact, we want you to go out and assess the impact.'"

"We didn't really know what we were going to find when we went back out," Fisher said. "We didn't know if we'd even see an impact. But there is a variety of scenarios where we could, and the only way to find out is to go down and take a look."

Diversity in the deep

The Gulf of Mexico has one of the world's most productive fisheries, and it is bordered by some of the fastest-growing counties in

the U.S. It is the country's single largest source of oil and natural gas. And it is also home to species of deep-sea animals, including many that have yet to be identified.

Ironically, many deep-water communities get their start thanks to some of the same stuff that humans want from the Gulf: hydrocarbons. In places on the bottom of the Gulf, methane and other hydrocarbons naturally percolate up from subseafloor reservoirs and seep out of the ocean floor. These so-called "cold seeps" are quickly colonized by bacteria feeding on the hydrocarbons. In the absence of sunlight and photosynthesis, the hydrocarbons provide a source of life-sustaining chemosynthetic energy.

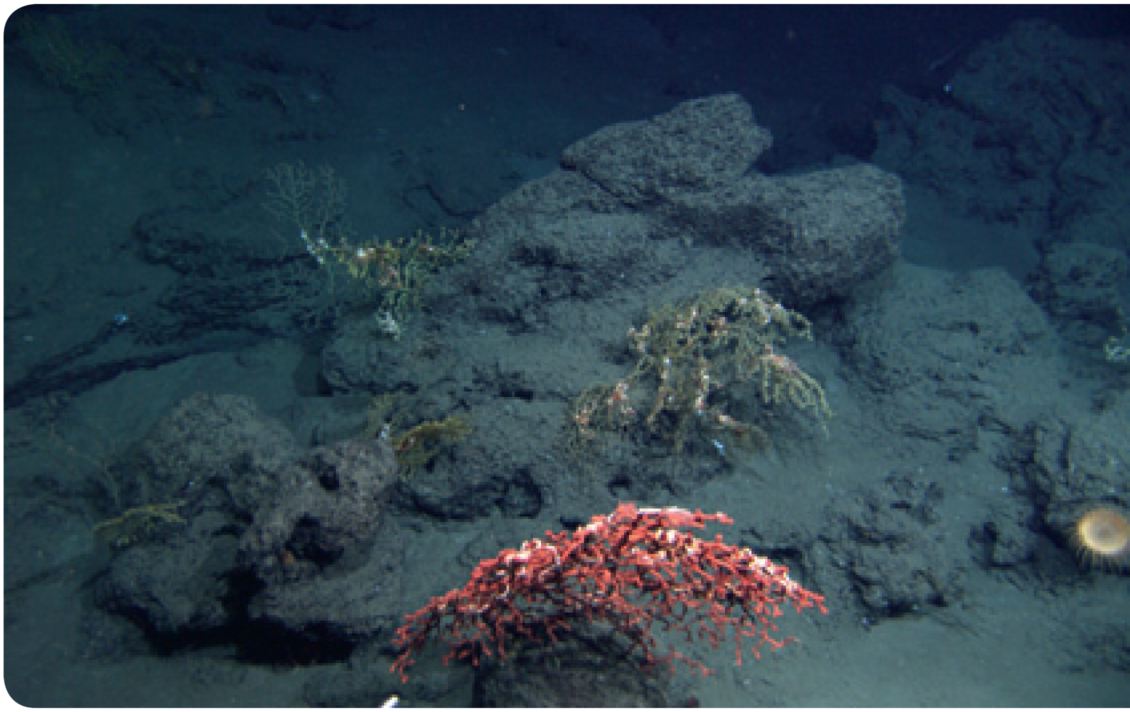
One of the metabolic by-products of these methane-eating bacteria is calcium carbonate (similar to chalk or clamshells). This material cements together grains of the soft, muddy seafloor, forming islands of hard, rocky ground on which corals can gain a foothold. The corals survive by feeding on particles that fall down from above or that drift past in the water. The corals then provide foundations for other life to flourish in the deep.

"Few people know we have deep-water corals in our oceans," Shank said. "They are extremely diverse and can form reefs that support lots of animals, a lot of diversity—more than 2,000 species worldwide. We don't know much about the ecology of these corals, but we do know they can live a long time and are extremely vulnerable to disturbance, like fishing trawlers, mining, or oil contamination. We also don't know what happens to the animals that rely on the corals if the corals are disturbed."

Catching a rain of particles

The goal of the original five-year research project was to learn how drilling might affect deep-sea life in the Gulf. It was funded by the National Oceanic and Atmospheric Administration and the Minerals Management Service, the predecessor of the present-day Bureau of

Cameras on the remotely operated underwater vehicle *Jason* took these images of a seafloor site about seven miles downstream from a plume of hydrocarbons flowing from the Deepwater Horizon/Macondo well. Scientists found deep-sea corals covered with brown flocculent material (top), oddly colored brittle stars tightly coiled on coral branches (left), and a red "bubblegum" coral (bottom) that appeared to have lost tissue in places to expose its white skeleton underneath. The scientists meticulously sampled and documented the site and returned a few weeks later with the submersible *Alvin.*



All coral photos courtesy of NOAA/BOEMRE Lophelia II project

Ocean Energy Management, Regulation, and Enforcement.

As part of the original project, the team had been scheduled to return to the Gulf in October 2010. But after the spill in April, German wanted to get back much sooner.

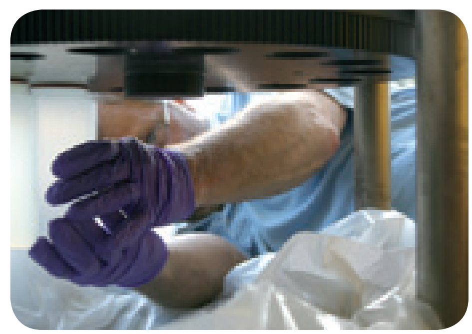
German's research focuses on how deep-sea ecosystems are sustained by two sources of energy: methane seeping up from the seafloor and particles raining down from the ocean surface. In September 2009, he had put out a pair of sediment traps directly above a deep-sea community in the Gulf to examine what was sustaining its growth. These funnel-shaped instruments are equipped with a rotating stage holding a series of cups to collect sinking organic matter that serves as food for the non-photosynthetic, non-chemosynthetic corals. The final cups were scheduled to close on July 2, 2010.

In the week following the explosion of Deepwater Horizon, German saw that the oil slick had drifted north until it was directly over one of his two traps. So Scott Worrilow, manager of the WHOI Subsurface Mooring Operations Group, was dispatched to the Gulf on an National Science Foundation (NSF) Rapid Response Research cruise to deploy two replacement traps—one beneath the surface slick and the other farther to the west. The new traps continued collecting samples at both sites as the spill progressed and the slick grew.

One of the traps failed, but fortunately the one beneath the slick was fine. It was retrieved and additional traps were deployed. When all the collected material is eventually analyzed, German should have an uninterrupted series of data from September 2009 to September 2011, capturing both the natural seasonal changes in food reaching the bottom and any disruptions caused by the oil.

The detritus in those cups could help answer some difficult questions. Did material from the surface slicks sink to the seafloor and affect the filter-feeding animals there? Did oil coating the sea surface block the sun and interrupt the regular supply of food on which deep-sea life in the Gulf relies? Or, conversely, any sinking oil may have provided hydrocarbon-eating microbes with "a whole bunch of free lunch at the bottom of the ocean," as German put it.

Matt Barton, WHOI



Matt Barton, WHOI

To learn more about what sustains deep-sea communities, scientists deployed funnel-shaped sediment traps (top) to catch particles of organic matter sinking down from the sea surface. WHOI researcher Steve Manganini (bottom) installs bottles to collect particles on a platform below the funnel. The platform periodically rotates new bottles into place. With data from before and after the spill, the scientists now can examine if and how the spill affected the rain of food to the seafloor.

A return with *Jason*

In October 2010, the research team returned as planned with the remotely operated vehicle *Jason*. Everything appeared normal on the bottom of the Gulf for most of the cruise, but on the last dive of the three-week expedition, *Jason* happened on a new deep-sea coral community. It was located about seven miles southwest of Deepwater Horizon, at the same depth and direction of a plume of hydrocarbons flowing from the damaged seafloor drill pipe. Other WHOI scientists had mapped the plume in June (see Page 28).

Shank was helping *Jason* pilot Matt Heintz collect samples on the final dive when he noticed a large red "bubblegum" coral that appeared to have lost tissue, exposing its white skeleton. "The coral next to it was covered with this brown, flocculent stuff," he said. Instead of healthy-looking brittle stars draping the corals' branches, the scientists also noticed uncharacteristically white brittle stars tightly coiled around the branches of the corals.

"I'd never seen this kind of posture in brittle stars anywhere among the dozens of

// SEE THE VIDEO @
www.whoi.edu/deepwaterhorizon/chapter6

> "Few people know that we have deep-water corals. They are fragile and host a diversity of animals."
>
> —*Tim Shank*

other coral sites in the Gulf, never seen this coloration before," he said. "They just didn't look right at all."

"We stopped everything," Shank said, "and we said, 'Something weird is happening here; it's not clear what. This is the closest we've been to the well, so let's just stop and treat it as a crime scene. We're going to spend the rest of our dive here and make sure we document this really well and get important samples for analysis back in the lab.' And that's what we did."

Enter *Alvin*

Within weeks of the spill, Shank, Fisher, and colleagues had submitted another proposal for a NSF Rapid Response Research grant to fund an additional research cruise a few weeks after their October voyage. By good fortune, the human-occupied submersible *Alvin* was already scheduled to be in the Gulf and was available in December.

A few weeks later, Fisher and German, who is also chief scientist of deep submergence research at WHOI, found that another vehicle could also be made available in December: the autonomous underwater vehicle *Sentry*. It was quickly enlisted to scout by night for deep-sea coral sites that *Alvin* could investigate by day.

On four *Alvin* dives in December, the scientists meticulously mapped, sampled, and photographed more than 40 corals in the unhealthy coral community that they had visited in October with *Jason*. They also surveyed a second, apparently healthy site nearby, which *Sentry* had found.

Dan Fornari, director of the WHOI Deep Ocean Exploration Institute, hustled to bring an ocean-bottom time-lapse camera into play at the site that seems to have suffered impacts from oil. It was set on the seafloor to help document any changes that may occur over subsequent weeks.

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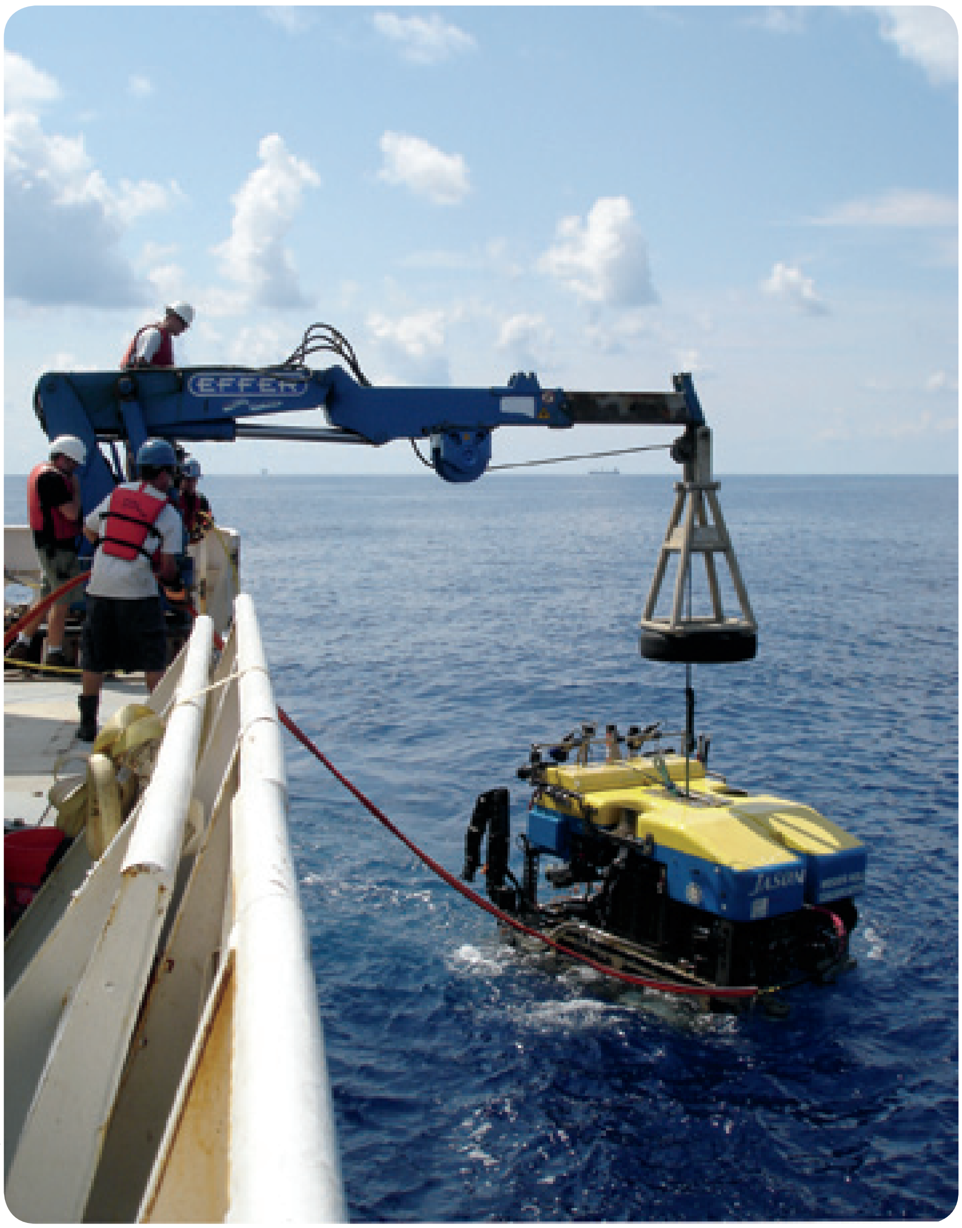
www.divediscover.whoi.edu/expedition13

The research team continues to look for more ways to turn its preparation and good fortune into knowledge. Various members returned in March 2011 with *Sentry* and a towed deep-sea camera system called *TowCam* to scout for more potential deep-water coral sites.

Sentry dove for 243 hours over 26 days and took 68,000 photographs. When *Sentry's* batteries were being recharged, *TowCam* made 26 surveys over 82 hours and took 35,000 photographs. The scientists found seven new coral sites and hundreds of previously unknown cold seeps.



Chris German, WHOI

The tethered deep-sea vehicle *Jason* was a workhorse on a research cruise in October 2010. Its lights and cameras documented deep-sea coral communities, and its manipulator arm secured samples of animals, seafloor sediments, and brown material enrobing some corals, which scientists suspect may be oil from the Deepwater Horizon spill.

In October, the scientists will return to the Gulf with *TowCam* and a remotely operated vehicle for up-close investigations of any damage caused by the oil spill on the marine ecosystem deep beneath the surface.

"A critical issue for us to learn about is the coral communities' resiliency and their ability to recover," Shank said. "They are fragile, and growing less than a micron a year, they can take hundreds, if not thousands, of years to grow back. Will these coral communities die out? Will some species recover and some not? This is going to be a study site for years to come. We haven't done enough, and that's why we're going back."

—Ken Kostel