Biologist investigates lasting ecological impacts of Deepwater Horizon oil spill

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This photo, taken as part of a major research project led by Penn State Professor of Biology Charles Fisher, shows a reef formed by the coral species Lophelia pertusa at 450m below the surface of the Gulf of Mexico with an orange brisingid starfish in the foreground and a school of fish overhead. Credit: Lophelia II 2010 Expedition, NOAA OER BOEM

Billions of dollars. That's what's at stake for BP as a result of the damage caused to ecosystems in the Gulf of Mexico from the Deepwater

Horizon oil spill.

News of that spill—which began on April 20, 2010, with an explosion onboard the Deepwater Horizon drilling rig that killed 11 people and injured 17—dominated the media for weeks. Millions watched with a feeling of helplessness as the rig sank and over the next 86 days over 200 million gallons of oil spewed out of the Macondo well and into the ocean.

Five months after the spill was capped, the federal government estimated the marine animal death toll at 6,104 birds, 609 sea turtles, and 100 mammals, including dolphins. But what of the deep-water corals that provide habitat and reproductive grounds for numerous species of fish, shrimp, and crabs?

According to Charles Fisher, professor of biology at Penn State, these corals and the organisms they support are important components of a healthy deep sea and open-ocean ecosystem. That's why both BP and the government are closely collaborating with him on his investigation of the disaster's impact.

"It's a new experience for me to conduct research that could have such a dramatic financial impact and also to have so many people involved in everything we do," says Fisher. "You have to be very careful to document all the details and be very sure that you're right with your interpretations. We're always careful, but every little comment we make could be misinterpreted, so we're being extra conservative with this data set."

Calling on a world expert

It was the middle of May, about a month after the oil spill began. With classes over, Fisher was looking forward to spending a little extra time on his farm, located 25 miles east of State College. But that was before the calls started to come in from federal agencies.

Over a period of about a week, Fisher was contacted independently by program officers from the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration (NOAA), and the Bureau of Ocean Energy Management (BOEM). All had financially supported Fisher's research in the Gulf in the past, and all were now calling on him to help assess the impact and damage of the oil spill to the deep-sea ecosystems he knows so well.

Fisher "was selected as an expert based on his extensive and unique experience working on the ecology of the cold seep and deep-sea coral communities in deep-sea, hard-bottom habitats in the Gulf of Mexico," says Robert Ricker, southwest region branch chief of NOAA's Office of Response and Restoration. "He is a recognized leader in his field, and we pick leaders."

Fisher agreed to help. After all, he already was leading another big research program that had overlapping goals—to locate, describe, and study deep-water coral communities throughout the Gulf of Mexico that could potentially be impacted by energy company activities.

For nearly three decades, Fisher has been studying the physiology and the ecology of the communities of animals that inhabit cold seeps—areas of the ocean floor where methane and other hydrocarbon-rich fluid seeps out—and hydrothermal vents—underwater fissures in the Earth's surface that emit geothermally heated water rich in reduced chemicals—in the deep sea. Marine invertebrates such as clams and tubeworms live in these dark places, surviving the lack of sunlight by forming symbiotic associations with bacteria. The bacteria use the reduced chemical compounds contained in the water as an energy source and, in turn, supply nutrition to their animal hosts.

Fisher has visited these deep places in submarines some 120 times. "When you're down there, you feel like you're on another planet because the landscape is like nothing you'll see on the surface of the Earth," he says. "You're oftentimes in a place where nobody has been before, so you have in the back of your mind that you may see something that nobody has ever seen. Every once in a while you do."

Among his accomplishments are the discovery of ice worms living on methane-rich ice at the bottom of the Gulf of Mexico and the unraveling of the complex physiological ecology of giant hydrocarbon-seep tubeworms, among the longest-lived animals on Earth. The bizarre two-meter-long tubeworms use their buried roots to suck up toxic hydrogen sulfide that lies deep in the sediments of the seafloor. They then pass the hydrogen sulfide to symbiotic bacteria living inside their bodies. These bacteria, in turn, oxidize the sulfide and provide nutrition back to the worms. The end product is sulfuric acid, which the tubeworms pump back into the sediments, where yet other bacteria use methane to remake the sulfide and supply it back to the worms.

Whenever possible, he works with Jim Brooks, president and CEO of TDI Brooks International, a company that specializes in conducting offshore surface geochemical exploration for petroleum producers.

"Jim's group discovered seep communities in the Gulf of Mexico in the 1980s when he was on the faculty at Texas A&M University," says Fisher. "I've been involved in multiple projects with him over the years. In addition to his expertise in oil geochemistry and prospecting, his company can handle all the administration, travel, budgets, and reporting, and I get to just concentrate on the science."

So in October 2010, with TDI Brooks International managing the expedition, Fisher and his colleagues set out for the Gulf of Mexico on board the NOAA ship, the Ronald H. Brown.

Discovering damaged corals

For nearly a month, the team revisited deep-sea coral sites all over the northern Gulf of Mexico that they had discovered the year before during a previous project. Each time they stopped, they used Jason II—a remotely operated vehicle (ROV) or submersible designed for scientific investigation of the deep ocean and seafloor—to sample and study corals and associated animals.

"We revisited all of the sites for which we had good baseline data," says Fisher. "We were all quite pleased to find that there was no obvious damage to the deep-water coral communities at any of these sites."

Although they had covered a four hundred-mile span east to west and a depth range from 1,300 feet to almost 6,500 feet, Fisher and his colleagues had observed only a couple of coral sites close by the Macondo well. So, on the last dive of the expedition they decided to check out a very promising area they had identified about seven miles southwest of the well and 45 miles from shore.

The research vessel coasted to a stop with nothing but the occasional seabird in flight to break the monotony of the view. Six hours into the ROV's dive, Fisher was working in the ship's laboratory, glancing up every now and then at the 36-inch screen through which video was streaming from the vehicle's camera, now positioned 4,500 feet below the ocean's surface. As the ROV moved across the seabed, the camera recorded scenes of mud, mud, and more mud, he remembers. Then, all of a sudden, a coral popped into view, and another and another. But something was wrong. The animals were not brightly colored as they are supposed to be.

Fisher recalls jumping up and sprinting across the deck of the ship to the control van. "Stop!" he warned. "Don't touch anything!"

The ROV pilots were about to take a sample, but he asked them instead to zoom in with the camera. What he saw were corals covered in dark gunk and dripping snot. "When a coral is physically insulted, it reacts by exuding mucus," he explains. "It's a normal stress reaction. It helps to clear the surface if there's something irritating or sticking on it." To avoid stressing the animals further, the team decided to minimize sampling.

"Normally we would take little pieces of lots of different corals for genetic identification and population genetic studies," Fisher says, "but we decided to back off on that and try to do our sampling around the edges, taking only samples of corals that we didn't recognize. We also collected one of the impacted corals so we could take a closer look at the gunk and what was underneath and determine whether the coral branch was dead or alive."

By the end of the cruise, the team had visited 14 sites, all but one of which were at distances greater than nine miles from the Macondo well. Only corals at that last site, just under seven miles southwest of the well, had clearly been impacted.

As the researchers headed home with their samples, they began to discuss future expeditions. They knew that impact to at least some corals could be readily identified visually and, since the organisms are attached to rocks and don't swim or float away when impacted, they provide a record of past events. Their next steps would be to discover the full extent of the oil spill's reach with regard to corals, and to determine the animals' ultimate fate. Would they live or would they die?

The impact

On five subsequent cruises over the next two years, Fisher and his team have explored for additional sites and revisited the established ones to check the corals' statuses. They have carefully monitored about 50 of the corals that they first discovered in November 2011. Those that were not too heavily impacted seem to be recovering.

"When I say recover," notes Fisher, "I don't mean that tissue died and the coral got better. I mean they were covered with slime, but they never died. These corals still do not look as healthy as corals at other sites, and we may have to monitor them for several years before we will know their ultimate fate."

The corals that were heavily impacted, on the other hand, are largely not recovering. "We are seeing absolute proof of total death of parts of them," says Fisher. Since corals are colonial, branching animals, parts of them can die while other parts remain alive.

The sea fan Callogorgia gracilis with the brittle star Asteroschema sp. in its typical outstretched form clinging to the coral branches. The coral is also colonized by a type of anemone (shown on the right side of the image) that grows on the dead branches of many species of deep water corals, and is a common natural occurrence. This coral and associated species were observed during leg 1 of an October 2010 cruise at approximately 300 meters depth, over 300 kilometers from the site of the Deepwater Horizon spill. Credit: Lophelia II 2010, NOAA OER, and BOEMRE, WHOI

Specifically, at the first damaged site they witnessed—the last site of the October cruise—the researchers have discovered that 86 percent of the coral colonies show signs of damage, with 46 percent exhibiting impact to more than half the colony, and 23 percent displaying more than 90 percent damage.

At each site visited, the researchers deployed markers and set up permanent monitoring stations with a goal of returning to them again and again to monitor both natural processes and, potentially, long-term effects.

"At that depth and at those temperatures in the deep sea, life passes at a slow pace," notes Fisher. "These are animals that often live 500 years. They live slow; they die slow. We'll have to monitor the sites for a decade before we'll have very much confidence we know the full extent of the impact."

What's next?

The team's second cruise, which took place in December 2010 and made use of the Alvin deep-diving submarine, included Helen White, a geochemist from Haverford College. White used state-of-the art oil fingerprinting technology and determined that the brown muck on the corals did, indeed, include oil from the Macondo well.

Fisher's research to date has demonstrated that the Deepwater Horizon oil spill killed some corals. As a result, BP is going to have to pay. But how much and to whom?

"People have asked me how much a dolphin is worth, and there is no clear-cut answer," says Timothy Zink, spokesperson for NOAA, the organization that oversees natural resource damage assessments performed by researchers like Fisher, tabulates the check for the parties responsible, and formulates and carries out a plan for restoring the ecosystem.

The sea fan Paramuricea sp. with the symbiotic brittle star Asteroschema sp. This apparently healthy coral was observed during the first leg of the October 2010 cruise at approximately 360 meters depth and over 450 kilometers away from the site of the Deepwater Horizon. Credit: Lophelia II 2010, NOAA OER, and BOEMRE, WHOI

"The public needs to be compensated for its losses, and not just for the resource itself, but for the human use of the resource—such as recreational fishing, bird watching, and going to the beach—as well," said Zink. "The final price that BP will pay will be based on the full cost of restoring the environment back to what it was on the day the oil spill happened."

Unfortunately for deep-water corals, the full effects of the spill may not be felt for many years, too late for any near-term settlement to fully cover them.

"I believe everyone involved would like to settle as soon as we can," says Fisher. "However, the full extent of damage to deep-sea ecosystems may not manifest itself until after a settlement is reached. If corals all over the deep gulf start dying, and we thought only those very close to the Macondo well would die, then we have to reassess the situation." In that case, Zink says, the investigation could be reopened.

BP has already paid over $20 billion to cover some of the damages from the spill, and in a November 2012 settlement with the Justice Department, agreed to pay $4 billioon in criminal fines. The company has also committed hundreds of millions to research into understanding the effects of oil spills on ecosystems and preventing future disasters.

Despite the trouble the oil spill caused for deep-sea ecosystems, Fisher says he's not against deep-water drilling for oil. "As much as I love the ocean, there are a lot of resources in the ocean, and as long as I drive a car, it would be pretty hypocritical of me to say that we shouldn't obtain those resources for human use," he notes. "I'm conflicted in the way I feel about it, but I don't think this means we should stop accessing oil in the marine environment.

"I think, in general, oil companies try pretty damn hard to be responsible." Fisher adds. "It's in their best interest to be responsible. This has cost BP billions of dollars; they don't want it to happen again. In a way, this oil spill has been a beneficial wake-up call in that it tells us that the unthinkable can happen. I think a result of it will be better oversight by oil companies and the federal government."

Provided by Pennsylvania State University

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