

GULF OIL DISASTER

Five Questions on the Spill

Sizing up the weeks-long spill in the Gulf of Mexico and its impacts is proving a challenge for marine and coastal scientists. The source is beneath 1600 meters of seawater, the winds and currents spreading the oil can be capricious, and the marine life in the oil's path is spread over hundreds of square kilometers, from the sea floor to the surface. Commercial fisheries have already been affected, and fragile coastal marshlands are at risk. Just monitoring all these ecosystems is the first challenge; gauging the toll taken and sounding the all clear will come later. Here are five of the key questions that scientists will be trying to answer over the coming months and years.

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For continuing coverage of the oil spill, see <http://news.sciencemag.org/oilspill/>

What's happening ... to the oil?

The magnitude of the catastrophe will depend on the oil's fate: the amount of oil released, how the oil is transformed chemically and physically, and how far and wide it travels. To date, scientists are far from answering any of these questions.

The oft-cited 5000 barrels per day of oil spewing from the leaking well is almost certainly an underestimate. Scientists eyeballing videos of the sea-floor gusher or gauging the extent of the surface slick in satellite images see five or even 10 times as much oil coming out 3.5 weeks into the disaster. Continued analysis will improve those estimates, and ongoing efforts to stanch the flow may be informative, but as one oceanographer puts it, for now, "it is what it is."

Researchers have a better handle on how the oil is "weathering." Samples collected from the sea surface show that, as expected, the oil is tending to lose its more volatile—and more toxic—components as it evolves from a simple liquid to an emulsified "mousse" to tarballs. Although well-aged tarballs are the least damaging form of lingering oil, those starting to appear on beaches are still so sticky that plants and animals could suffer greatly. Detergent-like dispersants applied offshore accelerate both physical and biological weathering, but chemists have yet to see obvious signs that dispersants are helping. Then there are biologists' concerns that dispersants could be affecting marine life in the open gulf directly through their toxicity or indirectly by causing more of the oil to linger far below the surface where fish and bottom-dwellers are.

Researchers could soon get a better idea of what's happening to the oil and dispersants as well as where it's all going as field sampling gets in gear. Reports of large subsurface plumes of oil—perhaps enhanced by dispersants—are beginning to come in as sampling from boats and ships is extended to the subsurface. And two different autonomous underwater vehicles are scheduled to start mapping subsurface oil using optical sensors; one of them can return water samples for detailed



analysis. The as-yet-loosely-coordinated effort to characterize the evolving spill is being conducted by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Geological Survey, while the National Science Foundation is supporting fieldwork through rapid-response grants.

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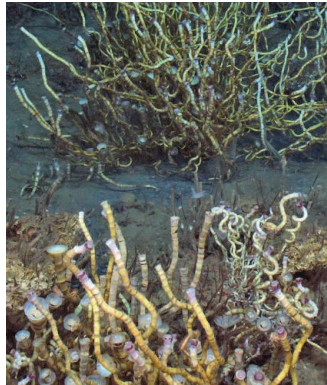
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... to life on the sea floor?

Two types of communities exist on the deep sea floor of the gulf. Where hydrocarbons seep out of the sediment, clams and mussels live with symbiotic bacteria that tap sulfide or methane for energy. In the same areas, polychaete tubeworms grow up to several meters long and can live for centuries. Elsewhere, corals capture prey that floats by or detritus that sinks from above.

Expeditions have sampled sea-floor biota in the Gulf of Mexico for years with submersibles and ship-borne devices. In mid-May, a research vessel operated by the National Institute for Undersea Science and Technology (NIUST), a university consortium, began taking sediment and water samples from areas under and near the oil spill. Another group already had a passive sediment-sampling device in place nearby. When they retrieve the device, by October at the latest, they will know how much oil has settled onto the sea floor, either directly or entrained in seaweed.

Most sea-floor studies to date have been funded by NOAA and the Minerals Management Service. NOAA is supporting the NIUST mission, which detected oil below the surface. The crew returned to port late last week and will begin analyzing samples. Meanwhile, they are beginning to plan another trip for follow-up sampling.



... to marine life?

Just after the spill, researchers at the state-funded Dauphin Island Sea Lab off the Alabama coast stepped up their existing research to trawl for plankton along a 56-kilometer stretch south of the island; they will repeat the survey every 2 weeks. Another ongoing study based on rigs near the spill uses underwater, company-owned robots to monitor the squid, crustaceans, and fish that dwell 200 to 2400 meters below the surface. Besides tallying deaths, academic scientists will look for changes in the animals' daily feeding movements.

An ambitious new study is about to start thanks to a rapid-response grant from the National Science Foundation. Working from two or three university research vessels, scientists from several institutions will trace oil over the next 3 to 6 months as it moves through the food chain from single-celled algae to large fish such as tuna.

NOAA is monitoring the spill's effects on the more than 20 species of marine mammals, notably bottlenose dolphins and endangered sperm whales, and five species of endangered sea turtles that call the gulf home. Besides checking for oil in and on the bodies of six dolphins and more than 100 sea turtles collected so far, the agency is conducting aerial surveys to count the gulf's dolphins and whales, and taking biopsies of one bottle-nosed dolphin population to determine baseline levels of the animals' exposure to oil and other contaminants. Scientists will also monitor mammals acoustically with an underwater device.



... to coastal ecosystems?



Coastal wetlands in the Gulf of Mexico have been under siege for decades. Chronic exposure to large amounts of oil could worsen their plight, killing marsh grasses and the creatures that live in the coastal sediment.

Three weeks ago, academic researchers took sod samples from an established field site just east of the Mississippi River. Now they plan to collect oiled sods from the same site and, in a greenhouse lab, compare processes such as plant growth, photosynthesis, and soil respiration. In June or early July,

the same team plans to survey sedimentation rates at 18 sites along the wetlands west of the Mississippi, an area likely to be hit by oil. A third study would assess the effects of fresh and weathered oil on different species of marsh plants; scientists say oil that has seeped into the soil and comes in contact with roots could have greater long-term impacts on vegetation than oil slicked on the surface.

In the shallow waters of Louisiana's Breton Sound, where oil has already intruded, effects on marine life may already be visible. A team will collect live mollusks for tissue analysis, examine their shells for changes in growth rates, and look for deformities in the husks of foraminifera, an amoeba-like bottom-dweller, and for large numbers of hibernating dinoflagellates in the soil.

... to fisheries?

On 18 May, NOAA shut down fisheries in a 118,000-square-kilometer area in the gulf. The move has threatened the lucrative shellfish industry. But the government says it is crucial to protect people from dangers of eating shellfish contaminated with polycyclic aromatic hydrocarbons, elements of oil that are carcinogenic.

Scientists are scouring the area for tainted catch—so far, with the oil still offshore, none has been found—a tricky task in itself. Current analytical methods take days. So scientists at AOAC International, a nonprofit analytical chemistry group in Gaithersburg, Maryland, are working with testing companies to try to develop faster methods for preparing and analyzing samples with mass spectroscopy.



A far more difficult task will be determining when it is safe to reopen the fisheries. After previous spills, NOAA has reopened fisheries when normal background levels of oil were detected in fish or shellfish samples. But given the size of the fishery affected and its critical importance to local livelihoods, such a strict standard may be unrealistic. Former Food and Drug Administration regulator David Acheson says the agency may have to develop new standards to certify fish that contains tiny amounts of oil above trace levels. But that could take "a very long time," he says. "We don't really know what's safe."