TAINTED WATER Oil floating in the ocean from the BP oil spill is captured in a plastic bag just off the coast of Louisiana.

REUTERS/CARLOS BARRIA/NEWSCOM

BP'S EVER-GROWING OIL SPILL

Environmental disaster in the Gulf of Mexico reveals U.S.'s inability to **PLAN FOR, CONTROL, AND CLEAN UP** oil spills in deep waters

JEFF JOHNSON, C&EN WASHINGTON, AND MICHAEL TORRICE, C&EN WEST COAST NEWS BUREAU

ON APRIL 20, less than a month after President Barack Obama announced a sweeping new federal program to promote offshore oil and gas development in the Gulf of Mexico and the Atlantic Ocean, the U.S. was hit with what has become the biggest oil spill in its history.

On that Tuesday night, 52 miles offshore of Louisiana in nearly 5,000 feet of water, BP's Deepwater Horizon exploratory drilling rig was closing down its operations. After months of drilling, it had reached a reservoir 15,000 feet beneath the seafloor, found oil and gas, and was in the process of capping the borehole with cement, sealing it for later commercial production, when a massive blast rocked the rig.

The exact cause of the blowout, fire, and explosion will be determined in the months ahead, but government and industry experts speculate that a cap of cement and drilling mud—used to seal the exploratory well—gave way to the pressure of oil and gas pushing up from the reservoir. The high-pressured oil and gas then blasted to the ocean surface, ignited, set the rig ablaze, and killed 11 workers.

Resting on the ocean floor, a key last-ditch safety device—the four-story-high blowout preventer—should have kicked in, pinching and closing the well. But when it failed to crush and block the borehole, BP, President Obama, and the nation could only stand by and watch the disaster unfold.

Just weeks earlier, on March 31, Obama had laid out his plan to expand offshore oil and gas exploration and development. He stressed the importance of balancing "the need to harness domestic energy resources and the need to protect America's natural resources," adding that he and Interior Secretary Ken Salazar "will employ new technologies that reduce the impact of oil exploration. We'll protect areas that are vital to tourism, the environment, and our national security. And we'll be guided not by political ideology, but by scientific evidence."

Obama's announcement surprised some of his environmental supporters, as well as elected officials from several coastal states, but the President appeared comfortable

in the knowledge that the U.S. had not had a major oil rig spill in the Gulf of Mexico, despite increasingly technologically complex drilling operations at record depths of a mile or more beneath the surface. Now, two-and-a-half-months later, the BP oil rig accident has set another record of sorts as the largest oil spill in U.S. history at more than 20 million gal, far outstripping the 11 million gal of the 1989 *Exxon Valdez* off the coast of Alaska and the 4.3 million gal of the 1969 Santa Barbara spill off California's coast.

The spill may soon rank as the world's biggest offshore blowout, surpassing the 1979 Ixtoc I rig spill in the southern Gulf of Mexico. That blowout, which released 138 million gal over nine months, also occurred when the blowout preventer failed during a well-sealing operation. Eventually, Mexican-government-run oil firm Pemex, the rig's owner, drilled relief wells and sealed the borehole, a fate increasingly likely for Deepwater Horizon.

BP's spill reveals shortcomings with the government's and industry's ability to plan for or control a deepwater leak, clean up the aftermath, and account for its environmental impact. Indeed, in testimony before Congress, well owner BP and drilling rig owner and operator Transocean repeatedly explain that they are learning more about oil spills through this tragedy.

The government has appeared unable to stop the flow or clean up the mess. Obama has had to rely on BP to even determine the size of the leak, estimates of which were far from accurate. BP estimated the rate at 1,000 to 5,000 barrels per day. Now, government scientists say the flow is 12,000 to 19,000 bbl per day, or 500,000 to 800,000 gal per day.

Yet Obama continues to support oil exploration and production, he explained at a press briefing on May 27. "Where I was wrong was in my belief that the oil companies had their act together when it came to worst-case scenarios."

AS IT CONTINUES unabated, the deepwater spill in the Gulf has exposed critical gaps in our knowledge of oil-spill science. Many questions have surfaced about the spill's long-term effects under the sea, on the surface, and on the shore. Experts' most pressing questions and concerns focus on possible underwater plumes of oil and the fate of small oil droplets created by chemical dispersants.

In the past month, several independent research teams have found evidence of underwater oil plumes. On May 12, scientists from the University of Mississippi and the University of Southern Mississippi aboard the *Pelican* research vessel reported the first signs of one—a six-mile-wide plume about 28 miles southwest of the wellhead and floating between 3,200 and 4,500 feet below the surface. More recently, a University of South Florida (USF) team detected what could be an even larger underwater plume about 42 miles northeast of the wellhead. Both teams mapped these plumes using fluorometers to detect the fluorescence signatures of the oil's aromatic compounds, along with either sonar or light-scattering instruments to detect oil droplets floating in the water.

However, the National Oceanic & Atmospheric Administration has remained cautious about calling these teams' observations underwater oil plumes and attributing the possible plumes to the spill. In a June 2 telephone press conference, NOAA Administrator Jane Lubchenco said that the agency wanted to wait for more definitive gas chromatography and mass spectrometry data on water samples collected by the cruises—along with others gathered by NOAA's own research vessels—before weighing in.

But a University of Georgia researcher, Samantha B. (Mandy) Joye, who worked with the *Pelican* team and has now returned to the Gulf on another expedition, reported on her blog that her team had collected water samples north of the wellhead that when filtered were shown to contain oil. These observations lend some credibility to the underwater plume hypothesis, says chemist Jeffrey Short of the Washington, D.C.-based environmental group Oceana. And on June 8, the South Florida researchers and NOAA officials announced that GC/MS analysis of samples from the USF expedition indicates oil at concentrations of about 0.5 ppm. But they could not yet confirm whether the oil had come from the spill.

Early media reports attributed the possible plumes to BP's underwater injection

Chronology Of A Catastrophe

April

20 Initial explosion on Deepwater Horizon exploration rig kills 11 people.

UPI/U.S. COAST GUARD/NEWSCOM

May

2 BP starts drilling first intercept relief well.

7 BP lowers containment dome over leaking wellhead, but methane hydrate crystals clog tube and the attempt fails.

UPI/PATRICK KELLEY/ U.S. COAST GUARD/NEWSCOM

12 Research vessel *Pelican* finds data that suggest a giant underwater oil plume.

15 EPA approves subsurface use of dispersants.

16 BP inserts tube into riser to siphon off a small part of leaking oil and gas.

17 Drilling of a second relief well begins.

22 Second explosion sinks rig.

of chemical dispersants at the source of the leak (C&EN, May 17, page 36). Dispersants are mixtures of solvents and surfactants that break up oil into small droplets, which stay in the water column longer than larger droplets. The underwater dispersant method had never been tried before this spill. Previously, planes had sprayed dispersants onto oil slicks to force the oil to sink below the surface so it was less likely to wash ashore and impact coastal environments. Gulf cleanup crews have also used this standard dispersant method.

Experts say that although dispersants probably enhance these plumes, the hovering underwater oil clouds could be caused by the spill itself. "When the *Pelican* showed those mile-long oil plumes, I wasn't surprised by that, because you're going to get natural dispersion," says aquatic toxicologist Carys L. Mitchelmore of the University of Maryland's Center for Environmental Science.

The reported underwater plumes fit with previous data discussed in reports of Department of Interior Minerals Management Service studies—including an experimental deepwater leak about 3,000 feet under the Norwegian Sea—and a 2003 National Research Council (NRC) report on oil-spill research.

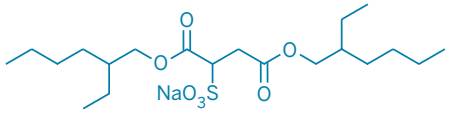
These reports found that the high pressure of oil released from a deepwater blowout causes droplets and bubbles to form. Natural gas also rushes into the ocean, joins the crude, and helps form a buoyant plume of oil and gas. As this plume rises, it pulls in dense water from the ocean's depths. Eventually, the denser water in the mixture slows the plume's ascent.

Because chemical dispersants injected underwater at the leak's source will create smaller droplets with more surface area per volume, plumes may rise even more slowly, says environmental engineer Eric Adams of Massachusetts Institute of Technology. A 0.5-mm-diameter oil droplet will take about two days to make the almost-mile-long journey to the surface, Adams says, whereas a droplet half that size will spend a week rising. Add in denser deep water and some dispersed oil plumes could spend more than a week in the water.

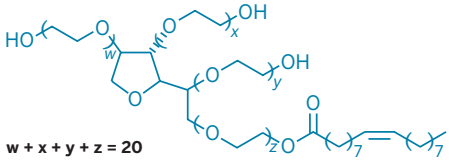
THE MORE TIME oil spends in the water column, the greater the amount of the oil's more soluble—and more toxic—compounds can dissolve into the ocean. The plume reported by USF researchers appeared to contain large amounts of dissolved hydrocarbons, according to a USF press release.

A stalled plume eventually breaks up and spreads out through the water column. Such traveling plumes concern Larry McKinney, the executive director of Texas A&M University's Harte Research Institute for Gulf of Mexico Studies. A plume that reaches upwelling areas, such as the De Soto Canyon 80 miles northeast of the wellhead, could spread oil even farther, because these regions act like conveyor belts that pull water and nutrients from deep waters to the surface. But any oil that doesn't degrade or dissolve into the water column will eventually reach the surface, Adams says.

To combat these surface slicks, BP has sprayed about 780,000 gal of chemical dispersants as of June 7 in an attempt to keep oil from hitting the Gulf Coast. Environmental groups and some scientists have raised concerns about this unprecedented rate of dispersant use. In the 1979 Ixtoc I blowout spill, crews sprayed about 2.5 million gal of dispersants onto oil slicks, but over a nine-month period.



Sodium dioctyl sulfosuccinate



Tween 80

In particular, observers have pointed to the toxicities of BP's dispersant choices, Corexit 9500 and Corexit 9527, as troubling. On May 20, the Environmental Protection Agency ordered BP to search for a less toxic alternative (C&EN, May 24, page 8).

Observers and EPA also demanded

UPI/A.J. SISCO/NEWSCOM

19 Order to restructure Minerals Management Service is signed.

20 EPA directs BP to find less toxic and more effective dispersants.

26 EPA calls for reduction in dispersant use and says it will look for an alternative.

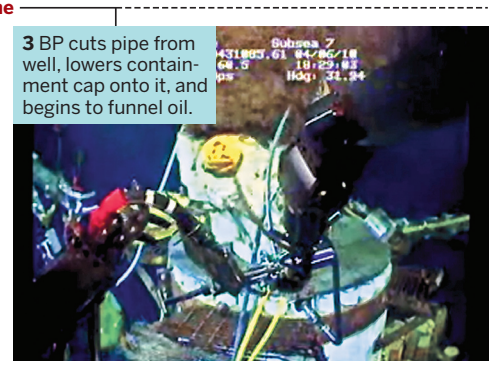
27 U.S. Geological Survey estimates leak to be 17 million to 39 million gal, making it the worst oil spill in U.S. history; Obama announces freeze on new exploratory drilling activities; and MMS head S. Elizabeth Birnbaum resigns.

29 Attempt to plug well with drilling mud fails.

June

3 BP cuts pipe from well, lowers containment cap onto it, and begins to funnel oil.

AP PHOTO/GERALD HERBERT



NEWSCOM

that BP disclose the chemical makeup of the dispersants. But the company initially refused, claiming that the compositions were the proprietary information of Nalco, which manufactures the Corexit line. On May 27, Nalco released Corexit's ingredients, and soon after EPA posted the information on the agency's Gulf spill site. The list reveals that the dispersants contain one ionic surfactant, sodium dioctyl sulfosuccinate, and three nonionic surfactants, Span 80 and derivatives of Tween 80 and Tween 85.

But most experts worry little about Corexit's toxicity. "Compared to the toxicity of the oil, the incremental increase in toxicity of the dispersant itself is pretty negligible," Oceana's Short says.

According to data on the 15 EPA-approved dispersants, the median lethal concentration, or LC_{50}, of Corexit 9500 for *Menidia beryllina*, a silverfish used as a standard toxicology test organism, is 25.2 ppm. The LC_{50} drops to 2.61 ppm when the fish

POLITICS

President, Some Members Of Congress Hope BP Spill Will Invigorate Energy Legislation Push

President Barack Obama and many Democrats in Congress are hoping the BP spill will refuel a drive to pass climate-change legislation that is now stuck in the Senate. But some in Congress aren't convinced, saying such a bill has a long way to go and should remain stalled.

Speaking on June 2 at Carnegie Mellon University, in Pittsburgh, Obama, pointing to the spill, underscored his Administration's record funding for renewable energy technologies in a focused effort to move the U.S. away from its dependence on fossil fuel.

He warned, however, that if demand for fossil fuels continues to grow, companies will go after increasingly challenging sources. "Risks are bound to increase," he continued, "the harder oil extraction becomes."

Obama added, "We also have to acknowledge that an America run solely on fossil fuels should not be the vision we have for our children and our grandchildren.

"The only way the transition to clean energy will ultimately succeed is if the private sector is fully invested in this future—if capital comes off the sidelines and the ingenuity of our entrepreneurs is unleashed," Obama said. "And the only way to do that is by finally putting a price on carbon pollution."

AFP PHOTO/JIM WATSON/NEWSCOM

IN THE TRENCHES Obama got a firsthand look at the unfolding environmental disaster hitting beaches along the Gulf of Mexico during a visit to Port Fourchon Beach, La., on May 28.

Nearly a year ago, the House of Representatives passed a comprehensive energy and climate bill that addressed carbon pollution, but the Senate did not, the President noted. "And, Pittsburgh," he continued, "I want you to know, the votes may not be there right now, but I intend to find them in the coming months. I will continue to make the case for a clean-energy future wherever and whenever I can. I will work with anyone to get this done—and we will get it done."

Immediately after Obama's speech, Sens. John F. Kerry (D-Mass.) and Joseph I. Lieberman (I-Conn.) praised the President and urged other senators to back their energy package, which includes carbon dioxide cap-and-trade provisions (C&EN, May 17, page 10). But no committee hearings or other actions on their bill have taken place since they introduced it a month ago.

Also speaking up after the President's speech was Senate Majority Leader Harry M. Reid (D-Nev.). In a statement and letter to eight senators who chair committees with energy jurisdiction, Reid said he supports the need to tie energy legislation to the BP spill, to reduce U.S. oil consumption, and to encourage renewable-energy technologies and manufacturing.

Reid asked the committee chairs to report back to him by July 4 on their views of what should be included in energy legislation, and he restated his intention to bring a comprehensive energy bill to the Senate floor by late summer. However, Reid made no mention of carbon dioxide reductions, carbon pricing, or cap-and-trade provisions.

Opposition from Republicans remains strong, with some, including Sen. James Inhofe (R-Okla.), a climate-change skeptic and cap-and-trade opponent, chiding Obama for his speech and his intention to push climate legislation, which Inhofe says will be a pointless drain on the economy.

However, other Republicans, such as Sen. Richard G. Lugar (R-Ind.), support Obama's position. Lugar announced in early June that he will introduce legislation to raise vehicle fuel-efficiency standards and encourage building and industrial energy efficiency. The bill is intended to cut U.S. dependence on oil, coal, and other fossil fuels but once again is short of effort to put a price on carbon.

It is yet to be seen whether Obama and his allies can focus growing anger over the spill sufficiently to drive Americans to support climate-change legislation that carries a hammer big enough to cut carbon emissions while also providing softer incentives to encourage energy efficiency.—JEFF JOHNSON

encounters oil dispersed by the chemical mixture, a 10-fold increase in toxicity over the dispersant alone. That trend is average for the 15 EPA-approved dispersants, and the ratio mirrors data on modern dispersants discussed in a 2005 NRC report.

The bigger environmental concern, experts say, is therefore not the dispersants themselves but what the chemicals do to the oil. By itself, oil is more toxic than dispersants alone, but less so than dispersed oil. In the Corexit toxicity experiments, oil alone had an LC_{50} of 10.72 ppm. When spill response teams approve dispersant use, they assume that the vast water column will dilute the dispersed oil and mitigate its increased toxicity.

Basically, experts believe that more toxic but significantly diluted dispersed oil floating in the ocean beats less toxic but concentrated oil slicks washing ashore. The 2005 NRC dispersant report describes this decision as a trade-off: Although dispersant-wielding clean-up crews expose water-column communities to the crude, they spare shoreline habitats.

THE GULF'S coastal wetlands are sensitive ecosystems that desperately require protection, experts say. About 40% of the contiguous U.S.'s wetlands line the Gulf of Mexico, McKinney says. "They are by far the most productive wetlands," he says. "They produce more seafood than the Chesapeake Bay, South Atlantic, and New England area combined."

Many of the region's important organisms, such as blue fin tuna and shrimp, use the wetlands at some point in their lifetime. Out in the Gulf's waters, adults breed during the late spring and early summer. Their eggs then float to shore and the larvae grow in the wetlands, protected from predators.

Because oil invading these sanctuaries would have significant repercussions to the organisms' life cycles, experts say exposing organisms in the Gulf's water column is the lesser of two evils. "The best solution is stopping the flow of oil," says Nancy E. Kinner, the codirector of the University of New Hampshire's Coastal Response Research Center, in Durham. "But until that happens, we have to do something."

As total dispersant volumes now top 1 million gal, however, some experts, including Mitchelmore and McKinney, wonder when response teams should reconsider this trade-off decision. Their concern is accentuated by the spill's timing: As oil continues to spew into the Gulf, many critical organisms have begun to spawn in surface waters.

In a June 4 report of a meeting sponsored by the UNH research center, oil-spill experts recommended continued use of dispersants, but suggested that response teams should establish ecological assessment teams to reevaluate the trade-off decision on the basis of data of dispersed oil-plume locations and concentrations.

But holes in the scientific literature hinder proper evaluation of the environmental trade-offs between wetlands and water column when massive amounts of dispersants enter the picture, other experts say. Some scientists believe that they can't properly estimate the harm that this

spill's load of dispersed oil will cause the water column, because they lack sufficient and fundamental data on how dispersants affect oil's fate, what creatures live in deep-water ecosystems, how laboratory toxicity tests translate to actual conditions in the ocean, and how oil affects organisms over the long term.

Dispersant-wielding response teams typically assume that the chemicals will enhance biodegradation of the oil by creating smaller droplets with greater surface area, thus providing microbes a better foothold to start colonizing. Microbes in the ocean, such as *Alcanivorax borkumensis,* see oil as just another carbon source and chew up specific compounds for food. These organisms evolved long before people started spilling oil into the sea by pursuing natural oil seeps on the ocean floor or the waxy hydrocarbons produced by plant life, says geochemist David L. Valentine of the University of California, Santa Barbara.

But behind those teams' assumption lie murky data. The authors of the 2005 NRC dispersant report described the results of three decades of research into dispersants' effects on biodegradation as "mixed" with studies showing evidence for "enhancement, inhibition, and no effect."

"Where I was wrong was in my belief that the oil companies had their act together when it came to worst-case scenarios."

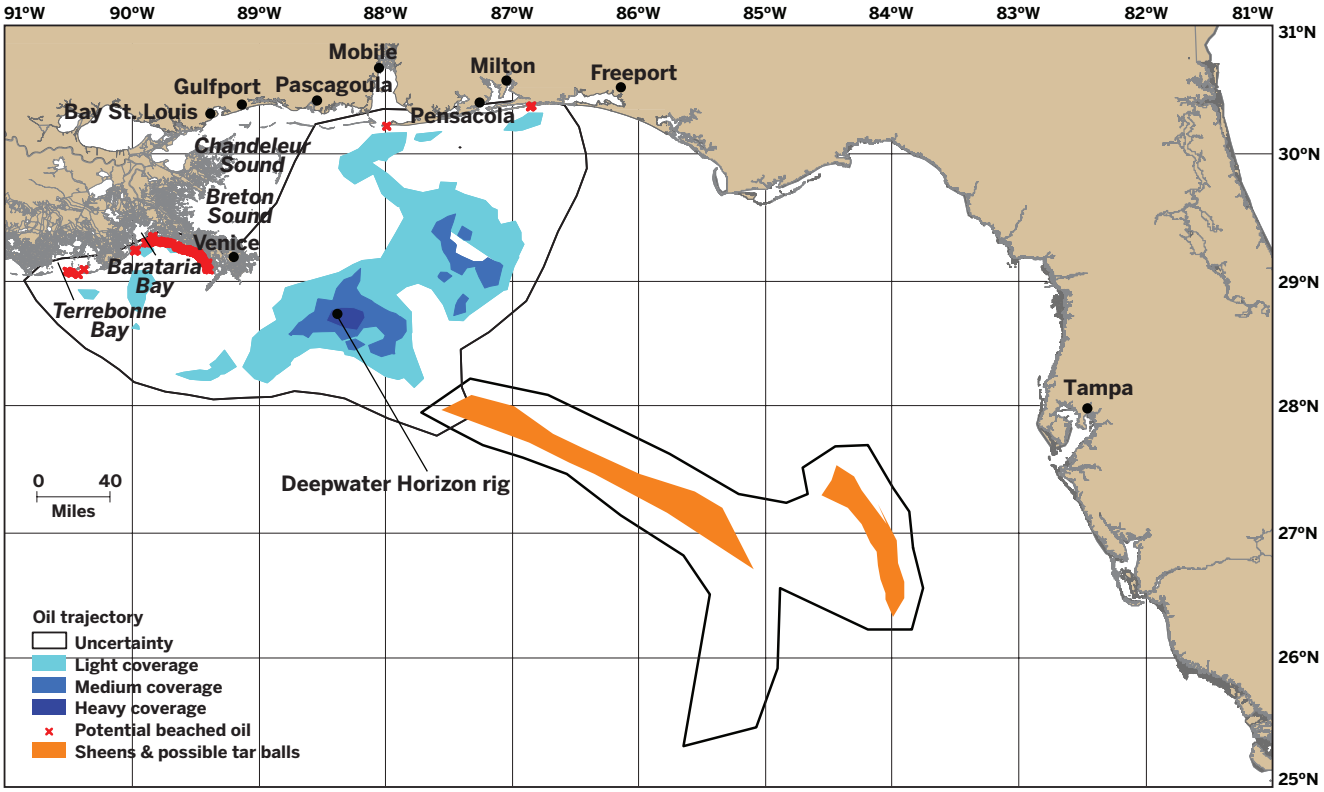
ONE SOURCE of confusion stems from the methods used to measure oil biodegredation. Studies often monitor drops in oxygen levels as a proxy for microbial activity, because microbes consume oxygen while they digest oil. Researchers question whether the lower oxygen levels could also signal that the microbes are digesting the dispersants' surfactant molecules instead of oil compounds. "If you look at structures of the surfactant molecules that are known, there are a lot of very edible pieces on there from a microbial perspective," Valentine says.

As contradictory biodegradation results hinder the ability of scientists to model dispersed oil's fate, missing pieces in toxicity data make it difficult to predict the spill's environmental impact.

First, the Gulf spill is exposing a relatively unstudied ecosystem—the deep ocean—to oil. Although biologists have studied organisms that live in the Gulf's wetlands and those that spawn in the water column, they have almost no data on the organisms that live at depths around the leaking wellhead. Also, aquatic toxicologist

SPILL STRETCHES ACROSS THE GULF

The area of the Gulf where surface oil has been detected is growing, and unmeasured underwater plumes lurk below



NOTE: Data as of June 4. **SOURCE:** NOAA

Mitchelmore says, it's unclear how many species living near the ocean's surface dive down to these depths to feed.

"Ultimately, we don't know what's even down there to ascertain risks," Mitchelmore says. "It is just one huge black box."

Harte Research Institute's McKinney recently sat on a Department of Energy committee that assessed the science and technology behind ultra-deep water oil exploration—in water deeper than 5,000 feet. He says that the committee assigned low priorities to biological surveys of deep-water communities. "It really didn't get a lot of attention," he says. "We're reaping the harvest of that [decision] right now."

EVEN THE TOXICITY data scientists have for species that live near the ocean's surface have question marks.

For example, laboratory toxicology tests often neglect one variable that organisms encounter out on the ocean's surface: sunlight. For transparent organisms such as planktonlike crustaceans called copepods, ultraviolet light from the sun can promote photochemical degradation of aromatic compounds from oil that the creatures have absorbed or swallowed. The products are oxidized molecules that are often more toxic than the original oil compounds. In tests to observe this photoenhanced toxicity, Mitchelmore says, researchers have found that the toxicity under natural light can be up to 50,000 times greater than the toxicity seen in a lab. So by neglecting real-world conditions, laboratory experiments could underestimate dispersed oil's toxicity.

Laboratory tests also mainly monitor acute, or immediate, toxicity of compounds in dispersed oil plumes. But organisms often encounter sublethal doses of toxic compounds that can cause long-term problems—what toxicologists call chronic toxicity.

When organisms absorb or even eat small amounts of oil over a period of time, their cells divert energy from growth and reproduction to defending themselves from the toxic oil. As a result, later in these organism's life cycles, they develop growth defects that limit their viability. Also because oil's toxic aromatic compounds act like narcotics or anesthetics, nonlethal doses can slow fish and disrupt their ability to respond to predators or to catch prey. "It's a more subtle way of killing something," Mitchelmore says of chronic toxicity.

The end results of chronic toxicity in the Gulf will probably take years to decades for scientists to fully appreciate, Mitchelmore says. But early signs may appear in the yields from next year's fisheries, she adds.

All of these now-glaring scientific unknowns have led experts to call for more oil-spill research to better prepare us for the next megaspill.

"This is one big ongoing experiment," Mitchelmore says. "We're going to be learning a lot from this spill, and that's wrong. We need basic information ahead of time."

Such calls have a familiar ring. After the 1989 *Exxon Valdez* spill off the Alaskan coast, Congress passed the Oil Pollution Act of 1990, which outlined a federal oil-spill research program. The law allotted $19 million per year for research, but, ac-

cording to a 2009 Congressional Research Service survey, federal agencies have spent significantly less; for example, agencies spent only $7.7 million in 2008.

More research will become increasingly important as oil exploration continues into unstudied ecosystems, such as ultra-deep water and the Arctic, Kinner and McKinney say. Understanding how oil behaves and what organisms could be affected in these new areas will be crucial.

Stakeholders from industry to regulators did not collect enough of this data before moving from continental-shelf drilling to deepwater drilling, McKinney says. Instead, they relied too much on what the community had learned from spills on the continental shelf and applied it to the deep.

"That was inappropriate," McKinney says. "There are huge differences, and we did not invest in an adequate risk assessment to make sure that we were balancing the benefits from the production against the potential environmental harm. And we're learning that harm the hard way now."

Obama underscored this lack of preparation for the worst and reliance on the past to predict the future at his late-May briefing. "The fact that oil companies now have to go a mile underwater and then drill another 3 miles below that in order to hit oil tells us something about the direction of the oil industry," he said. "Extraction is more expensive, and it is going to be inherently more risky."

The President then announced a series of potentially sweeping reforms within the Minerals Management Service, the part of the Department of Interior that oversees offshore oil and gas drilling and production in federal waters. Only hours before the briefing, Salazar had forced MMS head S. Elizabeth Birnbaum to resign.

Among reforms announced by the President and Salazar were new, tougher operating standards for offshore energy companies and a six-month moratorium on new deepwater drilling. The requirements were based on recommendations of a federal agency report, the so-called 30-day report, ordered by President Obama and completed on May 27.

THE MORATORIUM stops exploratory drilling in water deeper than 500 feet, half the depth normally considered to be "deepwater." Consequently, 33 permitted exploratory wells currently being drilled in the deepwater in the Gulf of Mexico must

UNWELCOME SPOTLIGHT

Oil Spill Leads To Fame And Fury For Makers Of Dispersant Chemicals

It's not quite the kind of attention that Nalco would have wished for. The water treatment chemicals maker has found itself tied to the disaster in the Gulf of Mexico because its products—a line of surfactants and solvent mixtures called Corexit—is the only dispersant being used by BP to break up the leaking oil.

As of June 6, responders had deployed more than 1 million gal of Corexit in the Gulf. Approximately 303,000 gal of that amount has been injected undersea at the location of the leaking well. The Environmental Protection Agency and members of the public have expressed concerns about possible toxic effects of using such a large quantity of the chemical in the Gulf's delicate marine ecosystem. In fact, on May 26, EPA ordered BP to reduce its use of the dispersant by 75%.

With more than 600 news stories mentioning Corexit by name, according to LexisNexis, Nalco has stayed busy issuing press releases confirming the low toxicity and safety of its product. And yet, "we're trying to make sure we don't get defined as a dispersant company," Nalco spokesman Charles C. Pajor says. "Normally, we don't even make that much of it—99% of our business has nothing to do with dispersants."

Pajor explains that Nalco provides a range of chemicals for the oil and gas production industry, and the dispersants are a small part of the product line. Most of the firm's business comes from selling chemicals and systems for reducing customers' water and energy use.

Although the majority of Nalco's employees are working on client sites, Pajor says, "we've got a lot of people who are dedicated to supporting the response effort to make and ship dispersants." He adds that responsibility for the use—or misuse, if any—of Corexit belongs to BP. "In the final analysis, the decision of when, how much, and how to apply the dispersants has always been up to BP. They are the experts and the ones on the scene," he says.

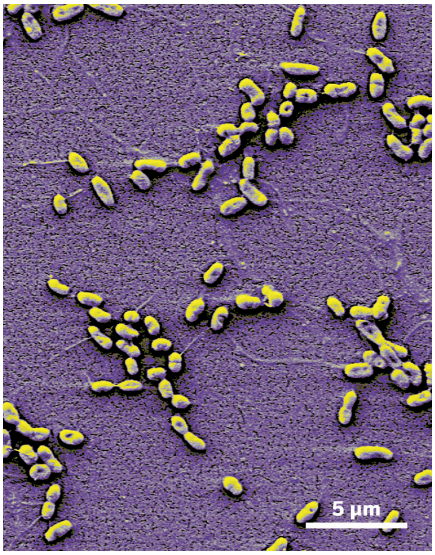
So far, the quantity of Corexit delivered to BP has brought in about $40 million to Nalco, or an additional 1% of yearly revenue, the company reports. That translates to an additional 8 cents of earnings per share for investors, according to Laurence Alexander, a chemicals analyst at Jefferies & Co.

But the reasoning behind BP's decision to use only Corexit is unclear—EPA has approved 81 dispersants and other products for cleaning up oil spills. One place Corexit is not being applied is near the shoreline. Nalco pointed out in a June 2 statement that Corexit should be used only in open water, at least 3 miles from the coast. Such restrictions do not apply to all of the approved chemicals. For example, SC-1000, described as a surface washing agent, is designed to be used to repel oil from shore.

Kim C. Kristoff, president of Gemtek, the Phoenix-based specialty chemical firm that manufactures SC-1000, says the product is a biodegradable alkyloxypolyethoxyethanol surfactant made from corn, soy, and palm oil. Because it is ionic, highly water-miscible, and lipophobic, it can be used to herd oil away from coasts and marshes or toward absorbent booms. The cleaner was awarded an EPA Design for the Environment designation in 2000.

Unfortunately for Gemtek, Kristoff complains, despite making more than 100 phone calls, he has been unable to interest BP's response team in the product, which was used in the 1989 cleanup of the *Exxon Valdez* spill. "Whenever they manage to stop the flow of oil into the ocean, just imagine the amount of three ships like the *Valdez* floating around in coastal regions," Kristoff warns. "It will eventually come to shore. What is their plan to get rid of it?"—MELODY VOITH

HEINRICH LÜNSDORF



BIODEGRADATION In the Gulf of Mexico, *Alcanivorax borkumensis* bacteria, shown in this colorized electron microscopy image, form biofilms and chew up oil's alkanes.

halt drilling at the first safe stopping point, Salazar explained.

But operating production facilities will be allowed to keep pumping, Salazar said. That means that some 3,500 production rigs and facilities operating in federal Gulf waters and 46 deepwater production rigs will keep working. Each rig can support multiple wells, so the actual number of operating wells is about 30,000, according to MMS budget documents.

MMS figures show that the deepwater wells are highly productive. Indeed, the recent 30-day report says wells drilled at those greater and technologically complex depths in the Gulf of Mexico produce 80% of U.S. offshore oil and 45% of U.S. offshore gas.

Salazar and MMS documents say only 55 federal inspectors are working in the Gulf, and they are expected to oversee drilling and production on 3,500 rigs and platforms. Salazar has announced his intention to increase by 10% the total number of MMS inspectors, currently 62, charged with the herculean task of overseeing operations on all the drilling rigs and production platforms operating in all waters in the Gulf, Pacific, and Alaska.

The exploratory moratorium will stay in place, Salazar said, until a commission created by Obama to investigate the BP oil spill has completed its review, which is due in six months. Much will turn on what this commission finds. Its charge is to examine the root cause of the accident and spill and make recommendations to improve federal laws, regulations, and industry offshore practices. The seven-member panel will be led by former EPA administrator William K. Reilly and former Florida Sen. Robert Graham. It is but one of a host of bodies examining the blowout, including BP, MMS, and the National Academy of Engineering.

Along with the exploratory drilling moratorium, Salazar canceled future lease sales in the Gulf of Mexico and a proposed lease sale off the coast of Virginia. Salazar also suspended proposed exploratory drilling in the Arctic region, which is expected to figure big in the future of international offshore oil production. Salazar said the Administration will take a "cautious approach" in the Arctic and, in light of BP's failure to control and clean up the Gulf spill, postponed Shell's proposal to drill up to five exploration wells in the Arctic this summer in the Chukchi and Beaufort Seas.

THE 30-DAY REPORT pointed to two primary failures in the drilling process that may have led to the BP disaster: the "loss of well control" and the failure of the blowout preventer. BP's blowout preventer had been modified to speed the drilling process, according to several reports.

Hence, Salazar ordered that blowout preventer equipment on all floating drilling rigs in the outer continental shelf must be reinspected and recertified to ensure that the devices will operate as originally designed and that any modifications have not compromised design or operation. Operators must also provide independent verification that the recertified blowout preventer will operate properly.

Salazar also announced his intention to separate MMS into three parts: an office for developing energy sources including wind and renewable energy, in addition to oil and gas; a bureau for regulatory enforcement; and an office to collect revenues from the use of federal lands by private companies. Last year, MMS collected $13 billion from oil companies producing in federal waters.

This conflict in oil and gas promotion, collecting revenues, and regulation has been a longtime problem for MMS but one that the Interior Department acknowledged only recently.

Created by Interior Secretary James Watt in 1982, the Minerals Management Service, as its name implies, was formed to collect and manage royalties for industrial activities in the outer continental shelf. Since 1982, it has collected more than $210 billion in revenues and distributed them to the federal treasury, states, and tribes. MMS oversees 11% of domestically produced natural gas and 25% of domestic oil.

About half of its $350 million annual appropriation for operations comes from collected royalties and fees. Also about half of its $60 million overall regulatory budget comes from fees charged to companies MMS is supposed to oversee.

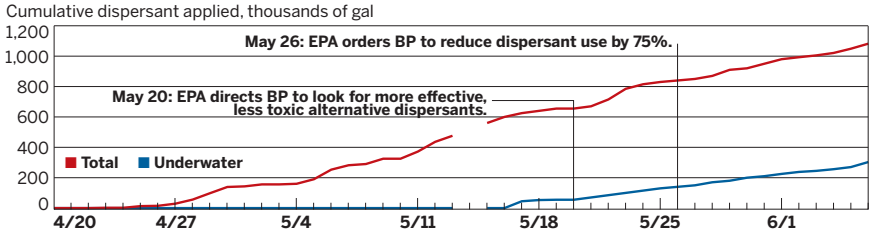
Last month, a report by the Department of Interior's Office of Inspector General found a busy revolving door between MMS inspectors and the oil rig operators and managers MMS is to regulate. Triggering the investigations were anonymous allegations of inspectors accepting gifts, including dinners, tickets for and transportation to sporting events, and hunting and fishing trips. The allegations also include falsification of inspection reports.

The report examined one company in particular, Island Operating, and its relationship with MMS's Lake Charles District Office, in Louisiana.

It found ample examples of company-paid social activities and MMS inspectors accepting industry jobs. However, the MMS district manager noted that the MMS in-

EVOLVING CLEANUP

BP has slightly slowed dispersant use after EPA's requests to cut back



NOTE: No data available for May 14. Data included only through June 6.
SOURCE: Deepwater Horizon Response, www.deepwaterhorizonresponse.com

CROWD-SOURCED CHEMISTRY

Scientists Use Social Networking To Study Spill

Watching news coverage of the Deepwater Horizon oil spill, chemists Adam Braunschweig, Mark Olson, and Amy Scott felt an overwhelming sense of helplessness. "We were sitting around talking about how we don't know what kind of chemicals and surfactants they're using," Scott recalls, "and Adam just came up with this idea: Why don't we test the water ourselves?" After all, she says, "we have the skills and the knowledge, and we have instruments lying around. Why can't we do this?"

So the three young scientists—all recent doctoral graduates—decided to establish Project Tantalus, an effort to collect and analyze water samples from the Gulf region and beyond aided by the power of Facebook.

For most researchers, Facebook is a place to turn when you want to kill a little time between experiments. It's not typically used as a research tool. But Braunschweig, Olson, and Scott realized that they were going to have to raise a small army if they wanted to collect water quickly from such a vast area. In today's digital age, what better way to do that than through Facebook?

With Facebook, Braunschweig explains, "you can spread your ideas to a large group of people, and you can ask that group of people to gather information that would otherwise be impossible to get." In this case, that information is water samples. "The situation changes from day to day, and we hope to monitor those changes," he says. "If we were trying to mobilize a group of people any other way, we wouldn't have an early snapshot. It would just take too long to get samples before things change."

Although it's just getting off the ground, Project Tantalus has a pretty ambitious goal: to collect 100,000 water samples from regions that have been or may be affected by the spill, including the Gulf of Mexico, the Caribbean, and the entire east coast of the U.S. The team is asking that participants collect at least six different samples of 5 mL each, taken at least 12 hours apart. Sample labels, which call for the date and time of collection, the longitude and latitude of the collection site, and a participant-generated random identification code can be found on Project Tantalus' Facebook page.

Depending upon location, the samples are sent to Braunschweig or Olson, who are about to start their own research labs at New York University and Texas A&M University, Corpus Christi, respectively. Scott, currently a postdoctoral fellow at Argonne National Lab, will be starting a postdoctoral fellowship at Columbia University in the fall.

The name Project Tantalus, incidentally, is derived from the Greek myth of King Tantalus, whose behavior at a dinner party thrown by the gods so angered his hosts that he was tied to a tree standing in a pool of water. Whenever he would bend over to take a drink, the water would recede, leaving him with an unquenchable thirst.

"The name is meant to get across the message that we're thirsty. Like Tantalus, all we want is water," Brauschweig says. "Our first goal is just to get people to send us samples from their backyards, and then we hope to develop some tests to see whether we can find some chemicals that are characteristic of the spill." If those prove to be successful, he says, "we could potentially track the movement of these chemicals. So it's an opportunity to do some very interesting science and gain a lot of information that maybe others could use."

"For the majority of the population, you can't do anything" about the oil spill, Olson tells C&EN. "This is an opportunity, I think, for people to get involved and be part of the larger picture." And if Project Tantalus turns out to be a success, he adds, social-networking sites such as Facebook could become regular research tools. "I think it's really far-fetched to assume that this is going to be the last ecological disaster of this magnitude. Who knows what's going to happen in the future? If we have something set up that's pretty robust and efficient, I think we could probably do great things with it," Olson says.

"This is exactly why you're trained as a scientist," Scott adds. "As a chemist, I feel that I have an obligation to protect our environment from harmful chemicals and pollutants. I think that it's important that this information gets out to everyone so people know exactly what they're swimming in or drinking, and along the way I'll learn some new science."—BETHANY HALFORD

spectors and company representatives "are all oil industry," are from the same part of the country, and grew up in the same towns.

"Almost all of our inspectors have worked for oil companies out on these same platforms," the district manager said. "They've been with these people since they were kids."

Also last month, Salazar announced he would request appropriations to more than double MMS's current budget for oil rig inspectors of $23 million to $52 million. He also announced he would seek legislation to eliminate a congressionally mandated provision requiring MMS to process all industry applications for exploration within 30 days. This narrow time window forces MMS to process applications without completing an adequate environmental review, which proved to be the case with the BP explosion. He proposed tripling the amount of time to 90 days.

Nearly all the reforms require congressional approval through appropriations and in some cases legislation. A hard road lies ahead. Congress is sharply split, with some members having deep and longtime ties to the oil and natural gas industry and the jobs and revenues they have provided.

As Congress works through drilling reforms, the Administration and BP are working to stop the flow of oil and clean up the oil that's already leaked. Until the relief wells are ready, which won't be until August, efforts such as the containment cap lowered over the leaking well early this month are being employed to capture some of the oil and gas billowing from the ocean floor. As for the oil plumes and slicks in the ocean and washing up on Gulf shores, chemical dispersants will continue to play a role in this cleanup. ■