The Science of Catastrophe

Making Sense of the BP Oil Spill

David Bond

It is this way of seeing that really counts.
—Raymond Williams, *The Country and the City*

"The Invisible Catastrophe"

One of the hardest things about studying the largest oil spill in U.S. history was finding it. On the ground, the BP oil spill was not always obvious. A television crew I met had been on the Gulf Coast for weeks looking for the disaster. All they found were tar balls and anecdotes, nothing spectacular. "Where is the oil spill?" they asked me. One marine scientist returning from a research cruise wrote an article for her hometown paper entitled "Lo Invisible de la Cátastrofe." The effects of oil were clear, she told me, but the oil itself remained elusive.

I eventually found the crude oil. I saw it used as a political prop in congressional hearings, I saw it tested in countless vials in university laboratories, and I saw it washed up on the shore of Grand Isle, Louisiana. It wasn't what I expected. I don't think it was what anyone expected. It wasn't black. When I saw it on the beach it was tan and glossy like melted caramel. Several rig workers on the Deepwater Horizon used the same word to describe it: "snot." The gushing oil of MC 252 was not a single thing; its complex composition splintered as it encountered the pressure of the deep sea and chemical dispersants. Sometimes the oil had the heavy scent of an auto mechanic's shop and sometimes it smelled as fresh as the ocean on a winter day. One scientist told me the crude oil looks like clouds of suspended particles floating along under the surface of the ocean. Another scientist showed me how the crude oil dissolved into the water and disappeared from sight. "If you don't see the oil and don't smell the oil it's hard to wrap your head around how big this disaster is," the scientist said.

Indeed, making this oil spill apparent is hard work. This spill doesn't quite register in the normal way (if there can even be a normal way to register environmental catastrophe). There is, as of yet, no iconic image, no defining moment, no commanding personality. It remains a fuzzy event. Nothing seems to jolt one into a sharp sense of its felt proportions. In the absence of something more convincing, the testimony of scientists has become a primary vehicle for making this event real. The BP oil spill is a haunting catastrophe made real again and again by scientific knowledge. The science of the spill, however, is a fraught field of knowledge.

The Future of Oil

The deep sea is breathing new life into the oil industry. A bustling energy frontier is taking shape in the depths of the ocean. The seabed, it turns out, is an ideal home for shockingly large oil fields. Turbidite sands and layers of compacted salt beneath the

Grande Isle, Louisiana, where oil washed ashore. A small army of media captured the event.

ocean combine to form a perfect geological structure for the huge crude oil reservoirs that many thought a thing of the past. This is especially true in the Gulf of Mexico. "The deepwater of the Gulf of Mexico can rightly claim to be America's new frontier and has truly emerged as a world class hydrocarbon province," MMS Regional Director Chris Oynes wrote in 2000. "Truly, the deepwater will drive the new millennium."

Today, wells have been drilled in water depths of 10,000 feet and soon rigs will be "operating in water depths up to 12,000 feet and drilling an additional 28,000 feet below the seabed"(NCBP 2010:12). Requiring advanced robotics and other sophisticated equipment to function at depths far beyond the limits of human travel, today's deepwater projects can cost upwards of four billion dollars. "Despite high initial costs, these projects can pay off in several years, or even months, due to flow rates exceeding 200,000 barrels per day of oil plus associated gas"(NCBP 2010:13). Discoveries in the deepwater have literally reversed the domestic energy fortunes of the U.S. For the first time in years, domestic oil production in the U.S. is growing.

This "hydrocarbon frontier" is at the center of my research. Focusing on the many uses of deepwater science, I'm investigating how technologies of the deepwater are expanding what counts as crude oil and the political repercussions of that expansion. A National Science Foundation RAPID Response Grant allowed me to compare the ideal federal response to an oil spill in the Gulf as worked out in preparedness workshops and contingency plans with the actual federal response to this deepwater oil spill.

It Started with a Hiss

As night fell on the Gulf of Mexico on April 20, the crew of the Deepwater Horizon was wrapping up a few remaining tests on a deepwater well they had just drilled for BP. Captain Curt Kutcha was host that day to BP executives who had flown in to award the rig's crew for their safety record and congratulate them on completing BP's latest deepwater bonanza: the Macondo Well. After a quick tour, the executives retired to the bridge and entertained themselves in what the captain later called "a big video game," the rig simulator. Below deck, Douglas Smith was filling out an equipment log in the engine room. In the next room over, electrician Mike Williams was talking with his wife on the telephone.

Hearing a loud thump and a hiss outside his shop, Williams hung up the phone. Gas alarms started going off as the engines revved into a deafening roar. "As I start to push back from my desk," Williams testified at the Deepwater Horizon Joint Investigation, "the computer monitor exploded in front of me. All the lights in my shop popped, the light bulbs themselves physically popped." As Williams ran for the door, "The engine goes to a level that is higher than I can even describe it. It's spinning so fast that—it stops spinning and there is a huge explosion."

Douglas Smith testified, "The first explosion basically threw me up against the control panel that I was standing in front of. A hole opened up underneath me and I fell down into the hole, into the subfloor where all the cable trays and wires are located." The first explosion blew the reinforced fire doors off their hinges, Williams recounted, "It blew the fire door and me across the shop." Crawling across the debris in darkness he found another exit. "As I reached the next door and grabbed the handle for it, it then exploded. That was explosion number two. That explosion pushed me back 30, 35 feet into another wall." As Smith climbed out of the subfloor "the second explosion happened. I ended falling back down in the hole and the ceiling caved in on top of me. I started hearing people screaming and calling for help."

Chaos ensued. Somewhere in the deep, natural gas had seeped into the well and rose with explosive velocity up the main riser pipe. It was later explained to me that while the volume of crude oil is relatively unaffected by changes in pressure, the volume of natural gas is radically altered by changes in pressure. One cubic foot of gas under the weight of the ocean will expand into over 300 cubic feet of gas as it rises toward the surface. As gas rushed up the mile-long, 21-inch diameter steel pipe, that surging expansion overwhelmed the built-in protections of the blowout preventer and the rig itself. Natural gas burst out of the rig floor and was sucked into the rig's main diesel engines. Fueled by that sudden influx of gas, the engines roared out of control until they exploded. The explosions obliterated part of the rig. Workers later recalled their surprise at finding an entire section of the rig missing as they tried to escape.

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The rig lost the ability to generate power and the well slipped out of their control. As flames engulfed the rig, communication onboard quickly broke down. By the time the captain gave the order to abandon ship most of the lifeboats were already in the water. Many workers were forced to jump off the rig into a toxic slew of drilling fluids and crude oil that now coated the ocean's surface. The rig began to tilt precariously as the fire burned out of control for the next 18 hours. Two days later the Deepwater Horizon rig was gone and a surface sheen of diesel fuel and crude oil began to appear.

Preparing for the Worst

On April 27, the still uncertain aftermath of the Deepwater Horizon was designated an "Oil Spill of National Significance" by Homeland Security. This designation places a federal emergency response team in control of the situation. The Oil Pollution Act (OPA) of 1990 governs the parameters of their authority. OPA, as one Unified Command official told me, gives the emergency response team two mandates: "Protect the public and protect the environment." He added, "We are more familiar with the front end of that. We are starting to figure out more about the back end."

Written just after the Exxon Valdez debacle, OPA beefed up federal agencies' abilities to collectively respond to an oil spill. Among other things, OPA directs key agencies to join together to prepare for the worst oil spill imaginable, and from that unified planning to construct a more exacting infrastructure of response. With federal agencies still grappling with the shocking destruction of Prince William Sound, the Exxon Valdez spill became the de facto worst-case scenario that this new and improved federal response team calibrated itself to remedy.

Environmental legislation often aims to protect against repeating the previous mistake. The last disaster becomes the new governing norm. As one government official explained, "What we apply to the next spill is what we learned from the previous spill." OPA is no different. Coming on the heels of Exxon Valdez, OPA legislated double-hulled tankers, navigational aid for major energy ports, and a more robust means of assigning liability. Much of the language in OPA reflects the particular setting of the Exxon Valdez spill and its iconic devastation. The ocean, for example, is treated as a corridor that can transport crude oil into sensitive sites like beaches or spawning grounds. The ocean, in the language of OPA, is a "pathway" to human and animal exposure. Nearly all of the technologies developed to combat maritime oil spills since then have focused on engaging crude oil on this pathway.

The problem, of course, is that the next disaster rarely follows the pattern we've prepared for. In federal preparations for the worst-case scenario oil spill, "the dominant image of Exxon Valdez became itself a problem," a government report recently concluded (NCBP 2010:16). "There was no logical reason that the accident in Prince William Sound should have been considered the worst-case scenario." With an imagination of future vulnerabilities rooted in historical particulars, the federal response team was unable to see to the emerging threats of the present. And at least initially, the catastrophe they saw was not the catastrophe unfolding in front of them. What they saw was what they were prepared for.

The Surface of Things

One of the difficulties federal officials faced in the Exxon Valdez disaster was a lack of real-time data on the size and flow of the oil spill. This dearth of data frustrated the allocation of resources to combat the spill and hampered the subsequent courtroom quantifications of damages done. OPA sought to remedy this. In the event of an offshore oil spill, OPA directs the National Oceanic and Atmospheric Administration (NOAA) to provide sound scientific advice to federal response efforts, especially on mapping the oil spill and the immediate threats it poses. NOAA, described to me several times as "the federal government's science agency," joined the federal response to the sinking of

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the Deepwater Horizon with the specific task of "gathering more information about the spill (amount, fate, and effects)" (NOAA 2010:1). With advanced degrees in oceanography and experience responding to oil spills, NOAA's emergency response personnel consider themselves experts in what they call "the science of oil spills." Once notified of an oil spill, NOAA moves quickly to produce data that can "inform operational decisions," as one scientist working for NOAA explained. The urgent pragmatics of containing an oil spill defines the work of NOAA scientists. They produce facts that can be effectively used.

As the gushing well in the Gulf continued unabated for one and then two and then three months, these operational facts soon became the most tangible handle on the reality of this difficult oil spill. NOAA's measurements became more than just scientific advice. They became headline news. NOAA, it was thought, had the world's best technology to produce real-time predictions of an unfolding maritime oil spill. Building on what they learned in the Exxon Valdez spill, NOAA developed over-flight and satellite survey techniques to measure a surface slick of oil with remarkable accuracy. With sophisticated modeling programs, NOAA is adept at predicting the trajectory of such a surface slick. Such information is crucial to preparing an adequate line of defense along popular beaches or sensitive wetlands.

The BP oil spill was, as more than one NOAA official described it, "unprecedented." Occurring nearly a mile underwater, this oil spill defied the official expectations of what a major oil spill should look like and how it should behave. Several months into the BP oil spill, a NOAA official admitted to me that the Exxon Valdez spill was where the federal response to an oil spill was stuck. We have the technology to combat the coastal mess of a grounded supertanker, he told me, but we do not yet know how to contain or remediate an oil spill in the deepwater.

The unique physics of the deepwater (and the added force of chemical dispersants) dissolved much of the gushing oil and gas into the water column. The ocean of this spill could no longer be treated as a pathway that enabled crude oil to wreak havoc elsewhere. The ocean of this oil spill was a sponge that absorbed the spewing hydrocarbons into itself. As oil and gas was violently integrated into the ocean itself, the chemical and microbial composition of the ocean began to fundamentally change. The environment that needed protection became exceedingly difficult to pin down. In the midst of the emergency response effort, federal officials found themselves struggling to define the nature of the ocean itself.

Seeing like a Marine Scientist

"This is not typical," Vernon Asper says as we look at underwater pictures of the Gulf of Mexico taken during the BP oil spill. Asper, a scientist studying marine particle fluxes at Southern Mississippi University, leans in toward a static of white dots in a photo near the floor of the ocean. "What is that?" he asks himself. We are flipping through a slideshow that his camera methodically captured as it descended to the ocean floor. In a three-hour cast near the wellhead, Asper captured a visual slice of the ocean. Just below the ocean's surface there are a few sparse white dots on an otherwise black screen. This, Asper tells me, is normal. Brown and red particles begin to appear as the camera is lowered a bit further. "Snotty aggregates of crude oil," Asper informs me, future tar balls in the making. A quick blast of brown covers the screen in a smog like haze for a few slides and then dissipates. Nearing 3,000 feet, white particles begin to appear and soon crowd the screen like stars on a clear, dark night. "A cloud of crystal particles," Asper says of the milky white mess. "We think it's methane hydrates," Asper says, "Tiny ice particles." After a pause he continues, "I stare at these pictures quite a bit these days.... There is so much about the ocean we just don't know yet."

Marine science is driven by what we do not yet know about the ocean. Unlike NOAA scientists who labor to produce operational facts to rein in an unfolding event, marine scientists work to produce disciplinary facts about a broad domain (to match more perfectly what we know of the ocean with the complexity of the ocean itself). While the knowledge of NOAA scientists is validated by its immediate application, the knowledge of marine scientists is validated through publication in peer-reviewed journals and citation in new research.

Marine science has been spurred on recently by a novel approach to the ocean itself. New research is showing the ocean to be a vibrant living system rather than a medium that contains life. In early summer, marine scientists working in the Gulf began to notice rippling changes in the chemistry and microbiology of the deepwater. Fluent in the interrelatedness of the ocean, they began working out a plausible link between microbes, the oil spill, and shifts in the chemistry of the deepwater that they were observing. Microbes consume hydrocarbons by drawing them into a chemical reaction with oxygen. This biologically mediated reaction consumes hydrocarbons and oxygen and produces carbon dioxide. As they breakdown oil, microbes alter the chemistry of the water.

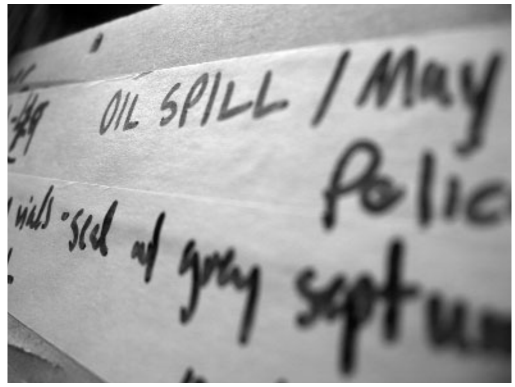
Focusing in on these changes, these scientists discovered plumes of dissolved hydrocarbons sprawling out from the wellhead. With technology attuned to monitoring the chemical and microbial makeup of ocean water, these scientists began to see what much of NOAA's technology was initially blind to. Well-versed in the dynamic nature of the ocean and able to observe its far reaches, marine scientists became essential interpreters of that growing disjuncture between the surface-centric technologies of NOAA and what was actually unfolding within the ocean itself. Although few intended to study deepwater oil spills, marine scientists possessed the perfect technology to monitor the unfolding consequences of just such a disaster.

In the laboratory, a post-doc prepares for a new round of testing. "I want to recreate what's happening out there," she tells me.

Crude oil being prepped for analysis.

A sample with discrete oil.

Inside 36 Pyrex glass bottles she is mixing various concentrations of deepwater samples of dissolved hydrocarbons with ordinary ocean water. “It’s like a controlled oil spill,” I comment. “My very own oil spill,” she jokes, “An oil spill in a bottle.” The degradation of oil evaluated in the Gulf so far suggests that the process underway has only just begun. The unfolding effects of this oil spill are new, but many marine scientists expect them, in a tragic way, to become the new norm. “So you are examining the very



Box of water samples.

A sample with diffuse oil.

beginnings of what you think will be a much longer process?” I ask. “Yes, that’s why I’m doing this experiment,” she replies. “So we can see that transformation.”

The Effects of Oil

“Have you seen the water samples?” a PhD student asks me. “They don’t look like oil. They look like clear water.” A few moments later a lab technician returned with a crowded tray of water samples labeled "BP Oil Spill." "They don't look like anything, they don't smell like anything," she says. "Normal sensory experience tells you its seawater." But when we ran it through the machines, she tells me, its hydrocarbon composition was "off the charts." "It's toxic," she summarized.

Developing new methods to locate and analyze ocean water laden with hydrocarbons, marine scientists inadvertently offered a new definition of what counts as crude oil in a subsurface spill. Focusing in on the altered chemical and microbial state of the deepwater, marine scientists devised their own means of discerning crude oil. Collating the effects, they redefined the cause. These emerging definitions, while illuminating the specific properties of crude oil in this spill, were at odds with NOAA's established means of defining crude oil. "Subsurface oil may be easy to identify in laboratories but it's very hard to locate in the environment," a NOAA scientist told a group of marine scientists. "Just because it's below your ability to measure," one marine scientist countered, "does not mean it's not toxic. We're seeing real effects on the ocean."

When I asked him about hydrocarbons in the deepwater, NOAA's Chief Ocean Scientist Steven Murawski explained, "It's a mile underwater. It's extremely hard to characterize what exactly is going on down there. And Unified Command wants to know for certain." While trying to measure the oil spill, NOAA employed a standard definition of what counts as crude oil. Marine scientists, in marked contrast, defined crude oil according to the specific chemical and microbial effects wrought by hydrocarbons in the deepwater. This discrepancy led to widening differences in estimates of the size of the oil spill and its potential impact. While NOAA officials were quick to suggest that most of the oil could have dissipated into benign invisibility, marine scientists quietly discussed the very real possibility of a slow collapse of life in the deepwater. Such a collapse could ripple upwards, a few scientists told me, strangling marine life throughout the Gulf of Mexico.

An Ocean under Siege

The ocean of this oil spill is far more than just a surface means of transportation for crude oil. "Through this all, we have witnessed an aged and untested bit of dogma dominate response decisions: Protect the beach," Oceanographer Robert Carney told National Geographic on August 19. "Quite obviously, it is the whole ocean that we must protect and effectively manage." Although there is a "gut reaction" to crude oil on the surface, marine scientist Samantha Joye told me, "I think when all the data is in, the subsurface effects are going to be far, far more extensive and far, far more long-term than the effects of the oil that made it to the surface." Oceanographer David Hollander echoed this point in a CNN interview on August 17. The BP oil spill, Hollander said, has "changed the paradigm of what an oil spill is from a two-dimensional surface disaster to a three-dimensional catastrophe."

In August, NOAA diplomatically invited marine scientists who had been researching the subsurface oil spill to a series of conferences. A White House official opened each session by reiterating this administration's unfailing commitment to "science-based decision-making." "We want to hear from scientists outside the federal family," NOAA Deputy Director Dr. Larry Robinson told the crowd in Florida, "We need your constructive input; help us solve a relatively large problem." Initially, NOAA's Charlie Henry admitted, the federal response was forced to move forward "with not a lot of good science." Now, he said, with surging research on the fate and consequence of subsurface oil, the problem has reversed itself. There is "a total mountain of information now out there," Henry said at a later meeting with scientists in New Orleans. "We are overwhelmed by the data on this spill. It's like a mosaic, but all I have right now are bits of glass. We need you to put it all together."

The daunting question became how to match this new sense of the ocean as a threatened living system with the operational mandates of the federal response effort. Although the environmental consequences of a deepwater oil spill had become terrifyingly unbound, it remained unclear what could actually be done about it. For the moment, the science of the oil spill had surpassed the art of cleaning it up.

Catastrophe as Grand Experiment

"Oil spills are uncontrollable science experiments," Charlie Henry told the crowd. It was the last of a series of meetings between NOAA officials and marine scientists. "We have an enormous experiment here," NOAA's Steven Murawski said. While a profound disjuncture marked how they initially

> **"We're going to be spending a lot of BP's money looking for the oil still out there."**

grasped the oil spill, NOAA officials and marine scientists were converging on what was now required. Now aware of the diffuse nature of hydrocarbons and learning to monitor their effects in the deepwater, NOAA officials and marine scientists were brainstorming on how the science of this spill should move forward.

"The bottom line is we need to learn from this one, we need new knowledge," Murawski said. With a flurry of new funding, a new science is taking hold. "Our toolkit has evolved tremendously in this spill," Murawski said. And of the remaining hydrocarbons he noted, "We're going to be spending a lot of BP's money looking for the oil still out there." ("BP has committed $500 million over the next 10 years to this thing called science," a BP official sardonically replied.) Rooted in an environmental catastrophe taken as a grand experiment, a new field of knowledge is opening up: an ocean fundamentally altered by the oil spill. And with it, a new field of operations to restore the ocean is being assembled. In the possibly more familiar language of Michel Foucault, the oil spill is producing a new domain of official knowledge: a damaged ocean (and the corresponding political responsibility to it).

"What is the science of oil spills?" Murawski asked. "It was a small community but now it is a growing community. A generation of scientists will work on this topic for their careers." He added, "Our colleague here is even doing an anthropology of oil spills."

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