Hurricane Katrina Response: Challenges to Scientific Support and Spilled Oil Behavior During Hurricanes

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Introduction

From space, hurricanes are visual wonders and a magnificent expression of the power of nature. Switch your prospective to being on earth and in the direct path of such a storm, and hurricanes can only be described as frightening. Hurricane Katrina was more than just frightening. On 29 August 2006, a weakened Hurricane Katrina with sustained winds approaching 230 km/hr and pushing a surge of ocean water some 9 meters high made landfall on the Northern Gulf of Mexico coast. One offshore weather buoy recorded 15-meter waves ahead of the storm's center. The storm was massive, with damaging winds extending 300 kilometers from the eye. After first crossing the Mississippi Delta, the storm again made landfall just east of Louisiana on the Mississippi coast destroying everything inland for several kilometers. To the west, the storm surge resulted in the failure of protection levees causing flooding to much of southeast Louisiana including 80% of New Orleans. Property damage estimates from the storm currently approach 75 billion U.S. dollars, and the loss of life was last reported at 1,383. In addition, the storm was estimated to have displaced some 50 square miles of coastal marsh. In Breton Sound alone, an estimated 30 square miles of marsh was converted into open water. And then there were the "disasters-within-the disaster".

The many oil spills and subsequent environmental injury are one such disaster-within-the-disaster event. Even before making landfall, Hurricane Katrina was wreaking havoc in the Northern Gulf of Mexico offshore oil and gas production. The United States Minerals Management Service (MMS) reported that 66 platforms were destroyed or severely damaged. The storm damaged some 100 offshore pipelines and resulted in a reported 211 minor offshore oil spills (a minor oil spill being less than 500 bbls). Fortunately, effective offshore evacuations resulted in no offshore-hurricane related deaths. Unfortunately for both the oil and gas industry and the coastal environment, the nearshore and inshore oil and gas infrastructure was also pounded by the storm resulting in hundreds of destroyed and damaged facilities. While a final quantitative assessment of facilities within state waters has not been reported, what is known is that the United States Coast Guard (USCG) responded as the lead Federal On-Scene Coordinator (FOSC) to 6 major oil spills, 3 medium oil spills, and 142 smaller (or minor) oil spills in southeastern Louisiana alone.

This paper highlights the challenges to responding to multiple major oil spills in the aftermath of Hurricane Katrina, the behavior of spilled oil during a hurricane, and the oil spill response role of the National Oceanic and Atmospheric Administration (NOAA), a partner with the USCG.

NOAA's Role in Emergency Spill Response

Since 1978, NOAA has provided a unique support role to the USCG for hazardous material and oil spill emergency response. NOAA is identified as a lead agency to provide scientific support to aid the USCG or U.S. Environmental Protection

Agency (EPA) during such emergencies. This relationship forms a mutually beneficial partnership since NOAA is also a natural resource trustee agency. NOAA's technical support includes hazard characterization, environmental chemistry, oil slick tracking, pollutant transport modeling, natural resources at risk analysis, information management, and assessment of environmental trade-offs related to alternative spill countermeasures and cleanup techniques. Traditionally, NOAA support is lead by one of nine Scientific Support Coordinators (SSCs) strategically located in field offices and ready to respond to spills in all U.S. territorial waters. The SSC is viewed as a direct consultant to the FOSC, a problem solver, a liaison to the larger scientific community, and an advocate for all natural resource concerns (not just those identified by federal law as pertaining to NOAA). Clearly, the magnitude of the Hurricane Katrina response stretched NOAA's conventional resources and contributed to the post-hurricane challenges.

The Challenge and Overcoming the Challenge

In the United States, the primary responsibility for cleaning up spilled oil falls to the owner of the product. The federal government's role is to provide oversight and work with industry to respond effectively to protect the public, responders, the environment, and property. Such cooperative response management is achieved using the Incident Command Systems with the affected State (in this specific case, the State of Louisiana) who also acted in an oversight and support role within a Unified Command. For most oil spills, even very large oil spills such as the EXXON VALDEZ oil spill in 1989, there is only a single responsible party. During the post-hurricane response, there were multiple potentially responsible parties and the USCG and State of Louisiana's Command Post

was physically separated from the actual spill locations by more than 100 kilometers and physically separated from individual command posts established by the different oil companies.

The size of the disaster combined with lost infrastructure was a challenge. Hurricane Katrina not only severely damaged the oil storage and transportation infrastructure resulting in multiple oil spills, but also displaced the industry employees and the co-operated and contracted oil spill response organizations. Much of the infrastructure in southeast Louisiana was destroyed or flooded. Initially, there were no operational cities, ports, or highways in the area impacted by the storm. Contingency plans were of limited value given that the staging areas and support infrastructure (e.g., equipment and personnel) was gone. Challenges to NOAA's traditional support were complicated by the loss of weather stations and damaged communication systems.

To meet the challenges, the USCG and NOAA brought personnel in from all over the United States. Scientist from all three divisions of NOAA's Office of Response and Restoration as well other NOAA field offices, such as the Office of Habitat Conservation's Restoration Center, responded as "One NOAA" to support the USCG and EPA. NOAA coordinated with industry to establish remote weather stations to improve weather forecasting for both spill trajectories and to support field operations and safety. Communications were improved with the use of satellite communication systems. Satellite phones enhanced remote field communications, and satellite communications networks were established to provide relatively fast internet links at field response command posts. Industry was viewed as a "partner" in the response since federal law and good environmental stewardship placed the funding for the response on the same

industries impacted by the storm. The Unified Command worked with industry to develop appropriate cleanup endpoints, develop strategies, and facilitate the maximum use of the response resources available. To complicate the response and add to the challenge, three weeks after Hurricane Katrina, Hurricane Rita forced a shutdown of all response activities and created a separate path of destruction in western Louisiana and along the coastal boarder with Texas.

Reported and Observed Nearshore and Inland Spills

As previously stated, USCG responded to 6 major oil spills, 3 medium oil spills, and 142 smaller oil spills in southeastern Louisiana alone. This effort reflects only the activities of the New Orleans Captain of the Port (COTP) Zone. The total volume of oil released from the 9 larger spills alone was reported as 190,897 bbls (or more than 8 million U.S.gallons). Murphy Oil in St. Bernard Parish and two separate spills in Lower Plaquemine Parish stand out to contrast the range of major spill responses.

Murphy Oil is located in the city of Chalmette, Louisiana – an area heavily flooded by the hurricane. When the floodwaters began to recede, oil began to release from a damaged storage tank containing a mixture of different crude oils. Of the estimated 25,000 bbls lost, 17,975 bbls were recovered from within the containment berms, adjacent ditches, and roadways. What made the Murphy Oil response unique was that approximately 1,800 homes in residential neighborhoods were also oiled.

In another incident, a pipeline at Nairn in Plaquemine Parish failed when a hurricane protection level was over washed and breeched during the storm. Over 3,300 bbls oil South Louisiana crude was reported lost, but the footprint of heavy contamination

in the adjacent marsh was limited to a relatively small area. Much of the oil was dispersed by the storm itself. The response was hampered by floodwaters and the access highway closed by both the floodwaters and two large fishing vessels stranded on the highway bridge at Empire. Nearby, but on the opposite side of the Mississippi River (where there had never been road access), were two very large circular oil storage tanks that measured more than 5 meters in height and 86 meters in width. During the storm surge, these two tanks floated, much like a large barge, toward the Mississippi River. Once the storm surge receded, both tanks lost the bulk of their contents due to structural failures. Some 90,000 bbls was lost, and unlike the pipeline incident, only a small amount was naturally dispersed. Some oil was lost down the Mississippi River, but most of the spilled oil was contained within the facility berm, adjacent canals, coastal marsh, and forested wetlands. Some 46,000 bbls were recovered by on-water response activities. *In-situ* burning was used to help mitigate a portion of the forested wetland due to inaccessibility.

Fate of Spilled Oil during Hurricane Katrina

The volume of oil actually released as a result of Hurricane Katrina was far greater than the apparent volume of oil observed during the post-hurricane surveys. A portion of the oil was naturally dispersed during the heavy seas and high winds characteristic of such damaging storms. The controlling factor as to which releases were highly dispersed was directly related to when the oil was released during the storm event and the oil release rate. Natural dispersion rates may have been nearly 100% for releases during the height of the storm. On the other extreme, damaged tanks may not have

leaked until the wind and waves subsided and flooding water receded. For the latter, natural dispersion was not a significant fate and facility containment systems often help contain large volumes of spilled oil.

To more completely understand the fate of oil released during the hurricanes, you must understand physical and chemical processes that affect released oil. Once oil is discharged into the marine environment, oil undergoes various physical and chemical processes that include spreading, drifting, dispersion, evaporation, dissolution, emulsification, photochemical degradation, and biodegradation. Spreading, drifting, and physical dispersion are physical transport factors. Processes that alter oil composition are collectively called weathering. Physical transport and oil weathering are closely linked. Light petroleum products such as diesel and condensate crude oils spread rapidly and are often removed from the ocean surface by evaporation and dispersion during even moderate sea conditions. When wind speeds exceed 15 knots, dispersion has a grater affect on oil transport and fate. Hurricane force winds combined with turbulent surface mixing and the force of large crashing waves would greatly enhance both evaporative loss and natural dispersion. If fresh, or unweathered, crude oil is released during hurricane force winds, very little oil would persist on the surface – most of the oil would be physically transported as small droplets into the water column.

Nearshore, hurricanes produce a large storm surge that completely over-washes and floods low elevation coastal areas. The marshes that compose most of the Mississippi Delta region were flooded during the passing of Hurricane Katrina and it took days before the receding water again exposed shorelines that are only inches to a few feet above mean sea level. As a result, released oil would not initially strand in adjacent

marshes because these areas were underwater. Spilled oil would have spread rapidly and undergone high rates of evaporation and natural dispersion. Large amounts of sediment kicked up by the turbulence would also scavenge much of the oil, and the surface flow and winds would spread what oil was not scavenged or dispersed over a larger area reducing observable concentrations.

For any oil release that continued after the sea state and winds lessened, and after the floodwater receded, that fraction of the spilled oil, persisted in the adjacent marshes creating footprints of heavy oil contamination. Damaged storage tanks may have leaked only a small amount of oil initially due to the hydrostatic pressure of water on flooded or partially flooded tanks. Since the berms are relatively high compared to the adjacent marsh land, residual oil leaking from the tanks began to collect in the berm and possibly overflow and strand in an adjacent marsh after the flood surge receded. In short, oil spilled during hurricanes is often rapidly dispersed. The most visible oil contamination after the passing of a hurricane is not a result of oil initially released, but by any oil that continued to release. It is likely that a large percentage of the oil reported lost from pipeline failures and storage tanks damaged by Hurricane Katrina was highly dispersed before the storm completely subsided. It would be impossible to provide an exact percentage for all incidents, but light to medium crude oils lost during the height of the storm would have been dispersed to nearly 100%. When the storm subsided, the response activities focused primarily on oil released after the height of the storm that collected near the original spill source. This may help to explain the reason that the visible footprint of heavy oil contamination in the coastal marshes was not as large as one might expect given the reported spill volumes.

The Post-Hurricane Cleanup Continues

Before the New Year began, 1 January 2006, most of the oil spill cleanup activities had passed to the natural recovery stage. Active oil spill cleanup activities had ended with the exception of small maintenance projects and private property issues (such as the oiled homes in Chalmette). Yet, the larger hurricane response continues. The recovery of thousands of stranded drums and storage tanks of oil and other hazardous materials from damaged oil production and support facilities deposited across the coastal zone is expected to continue for months. Orphaned drum and tank recovery should be completed by 1 June 2006, the start of the new hurricane season. Hurricanes are powerful storms and nothing new to the Gulf of Mexico. Hurricane Katrina will be remembered, and Louisiana will rebuild knowing that another hurricane may one day again threaten – such is the way of life in the Gulf of Mexico.