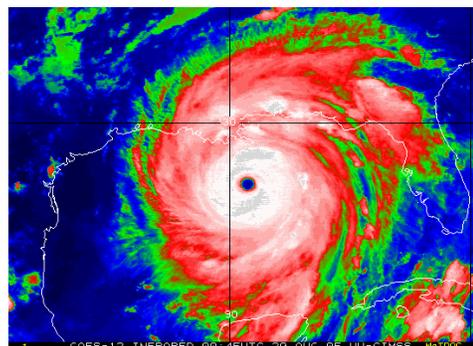


## Impacts of Hurricanes Katrina and Rita on the U.S. Offshore Energy Infrastructure

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### Abstract

Oil and gas exploration, development, and production facilities located in the Gulf of Mexico Region of the United States (U.S.) were subjected to category five hurricane-force winds during the passages of Hurricanes Katrina and Rita during the summer of 2005. Major fixed platforms and smaller production facilities were totally destroyed or severely damaged, moorings on mobile offshore drilling units (MODUs) failed, and both transportation and in-field subsea pipelines sustained significant damage. This paper will summarize the extent of the impacts of the hurricanes on the offshore energy infrastructure and what efforts were immediately undertaken and are still underway to return offshore U.S. crude oil and natural gas production to pre-hurricane levels. Emphasis will also be placed on the regulatory programs that the Minerals Management Service (MMS) has in place to prevent and limit oil spills from offshore facilities, requirements for hurricane operational planning, and procedures for post-event damage assessment and reporting. Lessons learned and best practices from responses to these precedent-setting natural disasters that affected the U.S. offshore energy infrastructure will also be shared.



### Minerals Management Service

The MMS is a bureau of the U.S. Department of the Interior (DOI) and is responsible for oil and gas exploration, development, and production in the Outer Continental Shelf (OCS) of the U.S. Covering an area of around 1.76 billion acres, the OCS contains about 19 percent of the proven natural gas reserves and 18 percent of the oil reserves in the U.S. Today, there are 8,200 active leases on 43,000,000 acres of the OCS that produce approximately 1.6 million barrels of oil per day (BOD) and 11 billion standard cubic feet of gas per day (BSCFD), representing 30 and 23 percent of the country's daily production, respectively.

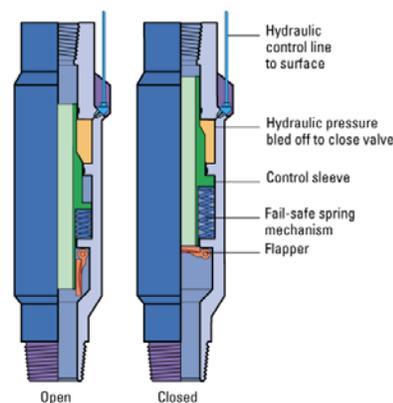
With a staff of around 1,700 employees, the MMS collects over eight billion dollars per year from lease sales, production royalties, fees, and fines. Staff of the Office of Offshore Minerals Management (OMM) branch of the MMS work in locations around the U.S. and are responsible for the oversight of all oil and gas activities and alternative energy projects in the OCS. The Regional Offices, located in New Orleans, Louisiana; Camarillo, California; and Anchorage, Alaska, conduct activities such as environmental and archaeological reviews, approve pipeline applications, issue Notices to Lessees (NTLs) to clarify regulations, publish safety alerts, and conduct lease sales, among other activities. The District Offices, located in New Orleans, Houma, and Lafayette, Louisiana; Lake Charles and Lake Jackson, Texas; and Camarillo, California, provide direct engineering oversight of offshore operations. Production, Drilling, and Workover Engineers review applications for installation, modification, repair, and decommissioning of platforms; drilling, workover, and abandonment of wells; and all related safety systems, and provide permits for proposed activities. District Offices are also the home to 68 inspectors that fly offshore daily to verify that oil and gas operations are being conducted as permitted and are in compliance with applicable Federal regulations.

The first well drilled from a fixed platform in the OCS occurred in 1947 in 16 feet of water. Today, there are approximately 4,200 fixed platforms or floating facilities, such as tension-leg platforms and semi-submersibles, in water depths exceeding 7,000 feet. Connecting these platforms to each other and to the mainland are approximately 33,000 miles of infield and transportation pipelines ranging in size up to 42 inches in diameter. Design guidelines for all offshore assets are established through MMS regulations, which, in many cases, adopt industry recommended practices.

### Hurricane Planning and Preparedness

One of the primary goals of MMS facility design and operational requirements following that of safety is the prevention of oil spills. Engineering analysis of proposed systems results in the establishment of maximum allowable operating and maximum working pressures to prevent overpressure situations. With the inclusion of pressure safety low sensors, swift identification of breaches of system integrity is assured and shut down valves can be activated.

The design of production strings in wells requires fail-safe close subsurface safety valves as a means to stop the uncontrolled flow of a well. Activated either manually through the Emergency Shut Down system or automatically by loss of control line pressure, the valve is part of a redundant system of valves that stops the flow of oil almost at its source when a platform is severely damaged or destroyed.



With the Atlantic area hurricane season running from June through September each year, and the Gulf of Mexico experiencing increasingly intense tropical storms or hurricanes, it is critical that operators have plans in place for the evacuation of the platform and the timely cessation of production operations. MMS regulations require that all production facilities which will be subjected to winds exceeding 74 mph (Category 1 hurricane) be shut in. As evacuation of personnel must be accomplished when helicopters can safely fly, some operators must shut in their facility upon departure. Other more sophisticated facilities, however, are equipped with Supervisory Control and Data Acquisition Systems (SCADA) that allow the facility to continue to operate even after all personnel have left the platform. Prior to departure, control of the facility is turned over to a remote onshore location where production can be monitored and controlled until shut-in wind criterion is reached. At that time the necessary shutdown sequence for the platform can be activated.

As authorized under the Oil Pollution Act of 1990 and Executive Order 12777, MMS is responsible for oil spill planning and preparedness for all facilities seaward of the coastline of the U.S., extending to the Exclusive Economic Zone.

Through the National OCS Oil Spill Program, MMS reviews and approves oil spill response plans for 175 operators in the OCS, conducts unannounced oil spill drills, monitors training activities of spill management teams and oil spill removal organizations alike, conducts field inspections of all oil spill equipment cited in oil spill response plans, and funds oil spill response research. Through the existence of



oil spill response plans, training programs, and both announced and unannounced exercises, operators are equipped with the necessary tools and skills to respond quickly and effectively to spills originating from one of their facilities in the OCS.

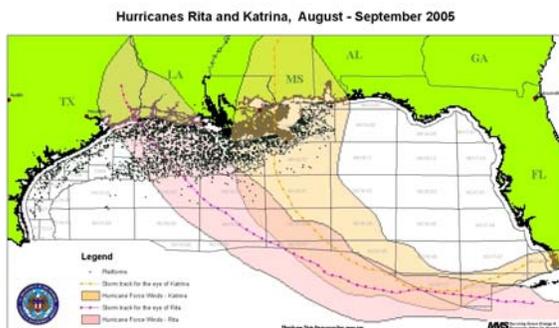
### **Storm Development, Characteristics, and Trajectories**

On the afternoon of August 23, 2005, the eleventh tropical storm of the Atlantic hurricane season, Katrina, formed in the Bahamas. In the ensuing eight days, the storm would grow in intensity to become a Category 5 (Saffir-Simpson scale) hurricane with highest sustained winds of 175 miles per hour (MPH).

Meteorologists reported peak wind gusts of 235 mph at the eye's core. Its path ultimately took it through the Gulf of Mexico and on into the Gulf Coast of the U.S., causing approximately \$75 billion in damage.

On September 18, 2005, the seventeenth tropical storm of the Atlantic hurricane season, Rita, formed and quickly intensified in strength as it moved into the Gulf of Mexico. At its peak, highest sustained winds were approximately 174 MPH.

During the next nine days, the storm would become the fourth most intense hurricane in the Atlantic in U.S. history. Again, the path of the hurricane was through the Gulf of Mexico, with landfall occurring to the west of the landfall location of Hurricane Katrina.



The paths of the two Category 5 hurricanes brought them directly through offshore areas that contain the highest concentrations of oil and natural gas facilities in the Gulf of Mexico, subjecting production platforms to Category 1 through Category 5 hurricane-force winds. It is estimated that approximately 22,000 miles of pipelines and 3,050

platforms were in the direct path of one, or, in some cases, both of the hurricanes. In fact, the centerlines of Hurricanes Katrina and Rita crossed one another creating an envelope in which scores of platforms experienced two separate periods of at least category 3 hurricane wind and wave forces. While buoys recorded waves offshore of over 55 feet, damage assessment on offshore facilities and statistical analysis of buoy data suggests that waves in some portions of the Gulf of Mexico may have exceeded 100 feet in height.

### Infrastructure Impacts

Damage assessment from Hurricane Katrina was in its early stages when the impending approach of Hurricane Rita necessitated the evacuation of manned platforms and in the cessation of production from facilities within the predicted path of the storm. Following passage of Hurricane Rita, the staff of the U.S. Coast Guard and MMS resumed overflights of offshore facilities to determine the extent of the damage to energy infrastructure and to locate oil spills resulting from both hurricanes. At the same time, owners and operators were also conducting over-flights to determine if it was safe for their workers to return offshore to bring production back on line, and to locate missing MODUs.

An assessment of damage to the offshore infrastructure revealed the worst damage in U.S. history. In total, 113 platforms were destroyed, with the largest portion being fixed facilities (78 percent). Only one deepwater facility was destroyed, although four sustained significant damage. A total of 52 platforms were also found to have incurred extensive damage from one or both of the hurricanes, with a preponderance of those damaged (88 percent) being fixed facilities.



While initial damage assessment of surface facilities was relatively easy, requiring a simple flyover, determination of the integrity of and damage to subsea pipeline systems has proven more difficult. At the time of the drafting of this paper, 309 pipelines were reported to be damaged, with varying descriptions of the level of damage indicated. Damage has been reported in shallow water, where simple clamp or spool piece installations are being performed, and in deepwater locations, necessitating repairs to pipelines in record-setting depths using the latest technology.

The state of MODUs following Hurricanes Katrina and Rita was one representative of a worst-case scenario for drilling companies who had jack-up and semi-submersible rigs on site when the hurricanes struck. Eight rigs were totally destroyed while 19 sustained extensive damage. During the height of both of the hurricanes, moorings of floating rigs separated and jack up legs failed setting a total of nineteen rigs adrift, an occurrence that resulted in their destruction or damage. In several cases, MODUs traveled over 120 miles, moving along the hurricanes' path toward land. Several rigs dragged anchors along the way impacting pipelines. With data



from geo-positioning systems located on many of the rigs, it was possible to chart their voyages over time and to identify when anchors snagged a submerged object and then monitor the rig as the anchor pulled free and resumed its hurricane-driven trajectory toward shore. To date, two MODUs remain missing.

In spite of initial, unconfirmed reports of catastrophic oil spills in the Gulf of Mexico, aerial surveys by operators, the Coast Guard, MMS, helicopter pilots, and the U.S. Navy, no major oil pollution events were found. The National Response Center (NRC), a federally-funded organization that is a one-call center for pollution events throughout the U.S., did receive and record 418 pollution reports affecting the OCS. A majority of the oil spills reported originated from platforms that were destroyed or damaged, or from leaking pipelines. The volume of oil that spilled, however, was limited to that contained within the specific well tubulars, platform flowlines, risers, and pipelines. In all cases, safety systems such as shut-down, flow safety, surface safety, and subsurface safety valves helped curtail oil spillage from damaged systems and successfully prevented uncontrolled flow from oil wells.

Resumption of production from offshore facilities following the hurricanes was not only hampered by damage to offshore platforms and pipelines but to onshore pipeline networks, tank farms, and refineries as well. At the time of the drafting of this paper, approximately 25 percent of U.S. offshore daily oil production and 17 percent of daily natural gas production remained shut in pending the repair of

either offshore or onshore components of the energy production and distribution system. In total, lost production from the Gulf of Mexico since the hurricanes has exceeded 119 million barrels of oil and 609 billion standard cubic feet of gas.

### **MMS Emergency Response**

With regulations already in place and reporting protocol well known to the industry, faxes, e-mails, and verbal reports on manning and production were being received by Gulf of Mexico Region staff as evacuations and platform shut-ins were taking place prior to Hurricane Katrina. To update and reiterate reporting requirements and to provide the status of MMS operations, the agency issued numerous notices to lessees (NTLs). The NTLs were published to the MMS web site ([www.mms.gov](http://www.mms.gov)) and were also forwarded to over 1,400 addresses of operators, government agencies, and public entities who had previously requested inclusion on MMS NTL distribution lists.

Through the real-time collection of data on the status of offshore facilities, MMS was able to prepare and distribute daily reports on production recovery. Reports on platforms, pipelines, and MODUs that were damaged, destroyed, and/or missing were also prepared and disseminated to the Coast Guard and other Federal agencies responsible for oil spill response and maritime safety.

The destruction of offshore facilities resulted in areas of the Gulf of Mexico littered with large amounts of debris, some of which were submerged and not visible from the water's surface. Regulations of the Coast Guard and the MMS require that obstructions be buoyed to alert mariners of possible hazards. In the aftermath of both hurricanes, however, three separate incidents occurred in which vessels struck submerged structures, leading to two significant events. In one case a survey vessel sank and in another a barge tankering fuel oil was punctured, eventually capsizing and spilling some of its initial 119,000 barrel cargo.



At the time of the hurricanes, the Federal, State, and local agencies, as well as oil spill removal organizations, were still in the process of determining how the new National Response Plan (NRP) would be implemented. While the plan, which has been developed by the U.S. Department of Homeland Security, had been under development for a number of years, its formal adoption in December of 2004 had put in place new, untested policies and procedures.

## Lessons Learned

The confluence of events surrounding Hurricanes Katrina and Rita created a worst-case scenario that impacted everyone in the Gulf Coast Region from Federal employees to first responders alike. Widespread destruction of telecommunications hubs made communications impossible. Travel was hampered by floodwater, destroyed bridges, debris in roadways, and restrictions placed on ingress to areas due to safety and security concerns. Homes and businesses were reduced to rubble or made uninhabitable, and public utilities were non-existent in many areas.

Prior to the entry of the Hurricane Katrina into the Gulf of Mexico, MMS activated its Continuity of Operations Plan (COOP), relocating key staff from New Orleans to Houston to continue, at a reduced level, normal operations. The path of Hurricane Rita then necessitated relocation of COOP personnel from Houston to Herndon, Virginia. MMS staff members were also dispatched to St. Louis, Missouri, and Baton Rouge, Louisiana to support efforts of the Coast Guard in oil spill response and recovery operations.

Through these inter and intra-agency efforts, MMS staff were afforded first-hand observations of working relationships within the response community, difficulties in data collection and dissemination, and myriad obstacles that a major disaster presents in adhering to standard contingency plans. Following are key processes identified by MMS as critical to a timely, well-orchestrated response to a worst-case scenario, focusing on internal continuity planning, support of first responders, and meeting the demands of public and private sources for impact statistics.

- Timely collection of accurate damage assessment data during emergencies can only be accomplished by pre-planned, well-publicized mechanisms.
- Inclusion of data in damage reports should be limited to sources which are known to be reliable and who have first-hand knowledge of data.
- Distribution of data updates should be performed on a scheduled, routine basis through a process that enables access by private and public entities.
- Uninterruptible communications systems must be in place prior to incidents of national significance to promote a coordinated emergency response.
- Data released by the Government for emergency response planning and/or public consumption, should be consistent and based upon one database.
- Development of emergency response plans are only the first step in preparedness, with success predetermined by dedication to exercises.

- ▶ Design standards for MODU mooring systems must be evaluated and improved in light of observed failures that set multiple rigs adrift in the OCS.
- ▶ Following search and rescue operations, industry must focus on the marking of submerged obstructions to prevent other safety or environmental hazards.

## **Conclusion**

Within a four-week period during August and September 2005, oil and gas facilities located in the Gulf of Mexico OCS region experienced two of the most powerful hurricanes in U.S. history. Approximately 3,050 platforms were subjected to sustained hurricane force winds and attendant storm surge. The resultant damage to fixed and floating platforms and subsea pipelines was extensive and repair activities to platforms and pipelines are still underway.

In spite of the intensity and enormity of both Hurricanes Katrina and Rita, sound hurricane operations planning and contingency plan execution led to the evacuation of all manned facilities in the Gulf of Mexico without any loss of life. Further, design of offshore platforms and pipelines and associated safety systems led to the loss of only nominal amounts of crude oil to the environment even in the face of unsurpassed damage to the energy infrastructure.