Remodeling the Gulf

Researchers are rethinking the weather of the Gulf to protect investments as well as lives.

By Alan S. Brown, Associate Editor
Hurricane Opal was a warning shot, but no one heard if for nine years.

Yet it helped spark a dramatic reevaluation of the Gulf of Mexico, and how to build and maintain offshore oil and gas equipment to survive its fury.

Opal slammed into the Florida panhandle in October 1995. Although characterized as a marginal Category 3 hurricane, its winds reached 125 miles per hour and its water surge crushed concrete buildings and pulverized a mile of highway.

The National Hurricane Center had tracked Opal since its inception. Over the water, it had been a Category 4 storm. Its central pressure, the motor that sustained its 150-mph winds, was lower than any storm that had not reached Category 5 severity.

Despite all they knew, Opal held a secret. "It was the top wave-making storm we had yet observed, but we didn't realize it until many years later," said James Stear, a specialist in Gulf of Mexico weather and ocean behavior with Chevron Corp. "For whatever reason, it was not flagged as a serious concern."

Perhaps meteorology-oceanography specialists had grown complacent. They had reason. With 100 years of storm data from shore stations, met-ocean researchers drove hindcast models that simulated the behavior of hurricanes at sea. They had validated their models against actual wind, wave, and current measurements taken as storms moved over Gulf waters.

They analyzed their models statistically to predict the largest storms the Gulf might see in five, 10, or 100 years. Then they translated the winds, waves, and currents of those storms into forces that would determine construction guidelines for production platforms, drilling rigs, and pipelines. The best platforms were designed to resist a 100-year storm.

"By the early 1990s, the industry felt it had a good hindcast model for setting standards," said Stear, who also chairs an American Petroleum Institute workgroup that is reassessing Gulf met-ocean conditions. "The models and data matched up pretty well, and we didn't think we were missing anything."

Opal appeared to fit existing models. It showed little evidence of unusual waves. No one looked any further. Then came Ivan.

The Crisis

Hurricane Ivan in 2004 was by far the largest wave-generating storm ever.

"We had never witnessed anything like it, according to the old hindcast model," Stear said. "Statistically, it was not out of the realm of possibility, but we decided to go back and look at our hindcast data."

The offshore industry had reason to be concerned. It was drilling and building farther and farther out from shore. Was its infrastructure in greater peril than it realized? Was it only luck that had kept it from being hit by another Ivan?

Met-ocean models relied on two different streams of data. Data from the 1950s forward took advantage of hurricane hunter aircraft, instrumented oil platforms and buoys, and satellite photographs. It was accurate, reliable, and plentiful.

The second stream, gathered before 1950, was based on readings as storms crossed land to enter and leave the Gulf. "We realized we didn't really know what the storm was doing in between those two points," Stear said.

BP has rebuilt its 50,000-ton Thunder Horse platform whose ballast system failed during Hurricane Dennis in July 2005. It won’t operate until 2008.

As met-ocean specialists reexamined their data and assumptions, they began to discern Opal's true ferocity. Then Katrina rocked through the Gulf. Like Ivan, it was a wave-generating giant. Unlike Ivan, it cut a path through the heart of the Gulf's oil-producing region, destroying 46 production platforms and damaging 20 more. One month later, Hurricane Rita knocked out 69 platforms and damaged another 32.

After Katrina, questions about met-ocean models took on a new urgency. "When we hindcast Opal, Ivan, and Katrina, we did not see these types of storm sizes and intensities," said Stear. "We had to ask whether we missed something in characterizing storms prior to 1950."

"When we went back to look at data, we found that the intensity of storms when they made landfall had not changed much. But when we look offshore over..."
the past 10 years, we found storms of unprecedented wave-making capability."

The industry went into overdrive. Within months of Katrina, the American Petroleum Institute issued a series of interim operating guidelines for the 2006 hurricane season. It formed the Hurricane Evaluation and Assessment Team to reassess the met-ocean environment, gather data about infrastructure failures, and revise structural guidelines. HEAT's recommendations will become part of a revised and broader set of structural and operating guidelines starting in 2008.

The Katrina/Rita devastation created a storm of pressures from outside the industry as well. The U.S. government sees the Gulf as a strategic asset that accounts for 30 percent of the country's oil and 20 percent of its natural gas. The government wants stability. Insurers want to reduce risk and will not stop raising premiums until they feel comfortable.

More profoundly, an industry of individual companies, each doing what was in its own best interest, suddenly awoke to find itself interconnected. Platforms are often within hailing distance of one another, producing oil and gas that runs through shared pipelines.

If a storm rips a floating rig from its mooring, it can smash into nearby platforms or rip a pipeline from the sea bottom. Companies that fail to implement best practices may not only lose their own equipment, but put other companies' assets at risk.

Money shows up even in something as innocuous as collecting data. When API's Hurricane Evaluation and Assessment Team requested information about infrastructure failures, not every company complied. This gave rise to some industry rumors—for instance, that the group had to hire contractors to go into offices and get the data because the companies didn't want to spend money to pull information. One source said, "They were interested in why platforms fail, but they're not in business to redo standards."

On the one hand, the industry is caught between the demands of insurers and the government, who represent higher costs, and on the other by the brutal economics of offshore oil production. Yet changes are coming, and coming fast.

According to Pat O'Connor, a senior advisor at BP and chair of API's Hurricane Evaluation and Assessment Team, the biggest change is in the understanding of the met-ocean environment. After Ivan, he said, the industry was in denial. Since Katrina, however, it has reached a consensus about Gulf storms.

API's new met-ocean model projects larger, more intense storms, although the jury is still out on why this is happening. Some researchers believe it is due to global warming. Others, like Stear, believe storms go through decades-long cycles of intensity. Whatever the reason, offshore storms are becoming more powerful.

They are not growing in intensity everywhere. The new met-ocean model divides the Gulf into four sections. The central zone, from Alabama to the Mississippi Delta, is hurricane alley. Here, the warm Gulf Stream enters the Gulf between Mexico and Cuba to form the Loop Current, which runs north before exiting south of Florida.

Met-ocean theorists believe that hurricanes stir up cold water from deep under the Gulf, which cools and weakens them. If they cross the Loop Current, however, the warm water causes them to intensify and grow larger. This may account for the central zone's large hurricanes. Storms in zones on either side of it are less intense. In the western zone, warmed dies that break away from the Loop Current intensify hurricanes only modestly.

"Our new guidelines request that companies operating in the central zone reassess their risk of failure now, and not wait for the normal triggers," O'Connor said. Meanwhile, API has been developing interim guidelines based on its new understanding of met-ocean conditions. This is not a simple process because each platform is unique in construction and location. Depending

![Image](https://memagazineselect.asmedigitalcollection.asme.org)
on when and where it was built, its upper deck may rise 70 feet or more above water level. Winds and waves buffet it from every direction, often changing in a heartbeat. Currents may suddenly shift, too, especially close to shore, as water pushed toward land seeks to escape by running parallel to the shore.

By carefully analyzing infrastructure failures during Katrina and Rita, API’s Hurricane Evaluation and Assessment Team has focused on vulnerabilities common to different types of Gulf infrastructure.

**Hit the Deck**

One suggestion focuses on removing “idle iron,” which might include such structures as unused risers, pipes, processing equipment, and boat landings. Eliminating the weight makes deep-sea floating platforms more buoyant. On fixed platforms, it reduces the number of targets for environment forces.

The lower decks of many platforms are also vulnerable. Large storms like Ivan and Katrina generate spiky, short-crested waves 70 feet high or more that can pop up from any direction.

“Most of a wave’s energy is in its crest,” said Frank Puskar, president of Energo Engineering Inc., Houston-based structural engineering consultants. Puskar heads the API Hurricane Evaluation and Assessment Team’s subcommittee analyzing structural failures during Katrina and Rita. “Decks are wide and flat, and when a wave is taller than a deck by even a few feet, it’s like hitting the deck with a flat board.”

Production platforms are built to take punishment. Their tubular members deflect wave energy around them. Lower decks are often built from metal mesh to let waves pass through them. All decks are designed with wide margins of safety, and to perform elastically when hit by a wave. Yet most were designed for smaller waves and are vulnerable to damage.

Producers can do several things to reduce vulnerabilities. One is to stop building auxiliary decks for additional equipment below the original lowest deck. The additional decks reduce the air gap between the sea and platform.

Puskar recommends removing as much equipment as possible once decks are in place. This reduces the amount of solid surface area and leaves behind only the open grating that doesn’t transfer nearly as much shock. It also keeps waves from smashing equipment, a common problem caused by Katrina and Rita.

**“When a wave is taller than a deck by even a few feet, it’s like hitting the deck with a flat board,” said one consultant.**

One company, Devon Energy Corp., is actually lifting two eight-legged fixed platforms an additional 14 feet above the water. The platforms, built 35 years ago, sit in 250 feet of water and were damaged by Hurricane Rita. The company uses 32 hydraulic cylinders to lift the platform while it welds leg extensions into place.

It sounds difficult, but as Verret observed, “Going to the moon is hard to do, but raising a deck just takes money.”

**Moving Targets**

API has also given tie-downs a lot of attention. A typical platform or drilling rig has lots of structures that rise from its surface. Derricks are usually the largest of them. During Katrina and Rita, many were vulnerable to the combination of high winds and acceleration caused by large waves.

According to Shawn Firenza, a product line manager for derrick builder National Oilwell Varco Inc. of Houston, “If you look at Katrina and Rita, I cannot think of a single derrick or mast that was just blown over.” Instead, he said, the entire drilling package—a derrick on a drill floor on top of an equipment module containing motors and transmission that sits on deck—is vulnerable to sliding. When that happens, it can crush or damage other equipment. When it comes to a sudden stop, the derrick can go right over.

Firenza is working with API to redraft its specifications to emphasize wind loadings on major equipment. “We’re doing wind tunnel studies to evaluate different methods of analysis,” he said. “The biggest difference we’re likely to see is how we look to wind shielding,
“Now, everything is interconnected,” said one expert. “The more structures we deploy, the more targets we have.”

how wind blowing on one structure affects the load on nearby structures.” He said that the new document will also include its first specifications on tie-downs to prevent equipment from shifting.

If tie-downs keep equipment on platforms from shifting, moorings keep floating platforms from moving. This proved a serious problem with Rita and Katrina. Rough seas pulled several floating platforms and, more frequently, mobile drilling units away from their moorings. Katrina dragged one MODU, Ocean Warwick, 66 miles to shore. Several companies spent days looking for free-floating rigs. While moving, those rigs could run into platforms or other MODUs, or rip apart pipelines while dragging their anchors.

It wasn’t supposed to be that way. MODUs are supposed to be able to jack themselves up so owners can tow them away from a major storm. It is one of the reasons they are usually designed to handle five- or 10-year storms, while production platforms are made to withstand 100 or even 1,000-year hurricanes. It is also why their less permanent mooring systems are vulnerable in big storms.

“Today, MODUs are taking on more challenging drilling work in deeper waters where they are more vulnerable,” said Alberto Morandi, executive vice president of American Global Maritime Inc., a consultancy in Houston. “That means they are staying longer in one place and they’re exposed way beyond their limits. Historically, they followed this practice and didn’t get caught until 2005.”

Morandi, who studied MODU and floating platforms after Katrina and Rita, said there is no predominant failure mode. Sometimes tension snaps a line, other times it pulls out an anchor. His API committee plans to recommend several changes, like using more anchors and using suction and other advanced anchors. He also advocates using polyester rather than steel mooring lines. Given miles of mooring lines, polyester, which floats on water, could significantly improve a rig’s buoyancy.

Making Assessments

API has also developed guidelines to help operators evaluate structures. HEAT has taken the information associated with casualties and figured out why those structures failed.

According to Verret, “Frank Puskar’s group has essentially used that information to develop a yardstick to see if your platform is in line for a heart attack.”

The system classifies platforms into three types. L1 platforms can withstand a violent hurricane. L2 structures can handle most storms, but probably not a 100-year event. L3 platforms tend to be minimalistic structures that should try to avoid a storm. “You can look at a chart, and if your platform was built in this year, from these materials, with this design, you’ll know where you stand,” Verret said.

According to Bob Bea, once Shell’s chief offshore engineer and now a professor of civil and environmental engineering at the University of California, Berkeley, inspecting and repairing platforms is still as much of an art as a science. He cited three problem areas.

The first has to do with inspection itself. “Typically, companies run a structural and fatigue analysis, then inspect the joints with the lowest fatigue life based on their model or a previous inspection,” Bea said. “They’d like to predict trouble, but 75 percent of the problems show up where they didn’t predict it.” He said he once found a garage-size compressor under a platform that had broken braces as it hurtled through the water.

After inspectors find a problem, they must analyze it to decide if it is serious or not. Bea said this situation becomes a problem because engineers use linear elastic analysis to build in safety factors during the design phase.

“But you can’t assume a damaged structure will perform in a linear elastic manner,” Bea said. “You need a more sophisticated nonlinear approach, but that takes more money, time, and education. So if you’re a small operator, do you want to hire an expensive engineering team to analyze the damage, or go to someone who’s faster and cheaper and will come back with an answer that says it’s okay?”

Repairs are the third issue. “A deep technology has evolved to make these repairs, but many people still put on a superficial patch,” he said. “A simple welded brace can actually do more damage than good, since it can reduce the platform’s elasticity. Then, when it’s hit with a wave, it goes right over.”

Bea also worries about the undersea oil and gas pipeline infrastructure that connects platforms to the shore. Many of the production problems that followed Katrina and Rita in 2005 were related directly to damage in that system. “No one has been watching the store,” Bea said.

“I remember when I started in this business and my production superintendent said, ‘How hard could it be to design a pipeline, just connect point A to point B?’ That was a tip-off to the problems that followed,” Bea said.

According to Bea, companies built to their own specifications. They often specified pipe thickness based on mill availability rather than on engineering reason. Despite the sophisticated stresses and materials involved, they rarely used advanced technology. “Today’s 33,000 miles of pipeline evolved rather than was engineered, and it is technically primitive,” he said.

When Katrina and Rita hit, many pipelines near the Mississippi Delta failed as the water churned the sea floor, which has the consistency of pancake batter. Far-
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Devon Energy's Nansen production platform is in 3,500 feet of water off the Texas coast. While Nansen survived hurricanes, other floating platforms did not.

ther from shore, on firmer seabed, rapidly moving water attacked pipelines that had not been buried.

There are solutions, but again, they cost money. One solution, Bea said, is to attach strakes. These act in the water like the helical supports on refinery columns and power plant smokestacks that keep wind from inducing dynamic vibrations. According to Bea, “Laying pipe with helical strakes is expensive, and if you weigh down the pipe with a concrete coat to get more weight on the bottom, it gets even more expensive.”

An Emerging Community

Bea sees money issues in securing pipelines and doing proper inspections. Others see the same risk and reward equation in minimalistic structures. Yet like it or not, both the government and the economy's invisible hands are pushing the industry to reconsider its operations in the Gulf of Mexico.

The government is demanding greater stability. The Gulf is, after all, one of the nation's greatest resources, supplying 30 percent of its oil and 20 percent of its natural gas. Gasoline and heating oil prices spiked in the aftermath of Katrina and Rita. By improving the structural integrity of its offshore infrastructure, industry can perhaps avoid an upset like that again.

Producers clearly want to protect strategic assets. That is why Devon went to the trouble of raising the decks of its 35-year-old platforms. Others are making critical, if less impressive, improvements.

The big change may come to operators of marginal platforms that don't make enough money to justify major reconstruction, or minimalistic structures that exploit small reserves. In the past, they took the risks and wrote off the losses. Now, under the whip of more powerful storms, government pressure, and rising rates from insurers—who after 2005 truly understand their risks—many are reevaluating their operations.

As Morandi of American Global Maritime explained it, “In the past, everyone would shut their wells to minimize pollution and evacuate everyone so no lives were lost. That might cost them a platform, but they could live with that.

“But now, everything is interconnected,” he said. “The more structures we deploy, the more targets we have, and the more likely that if one breaks away from its moorings, it will impact the others. We flow production through pipelines and hubs at shallow-water fixed platforms, but even floating production systems that survived the hurricanes couldn't produce if those fixed platforms were damaged.

“In the past, the industry thought of the Gulf as a collection of individual structures,” Morandi said. “Today, there's a new paradigm, a fleet of interconnected structures.”

And that new paradigm may be the biggest change created by the great hurricanes of the past few years.