Deepwater Horizon oil spill

Ten years of scientific research

The Gulf of Mexico Research Initiative (GoMRI) was developed in response to the Deepwater Horizon oil spill in 2010. With the impacts felt by the community and environment alike, a decade of scientific research has worked to improve the world's knowledge of oil spill science and further our understanding of the biological, chemical, and physical parameters that control the spread and impacts of oil spills in both the short and long term. Through collaboration, the world can be better prepared for future oil spills and mitigate their severity.

A decade on from the Deepwater Horizon oil spill that insulted the Gulf of Mexico, an international, interdisciplinary network of collaborators celebrate scientific advances made with the Gulf of Mexico Research Initiative (GoMRI), headed by former United States National Science Foundation Director, Dr Rita Colwell, and an independent Research Board. Through $500 million of funding, research opportunities have allowed academics, industry, governments, and independent organisations to improve their understanding of oceanographic and ecological processes that sustain the Gulf of Mexico's precious marine ecosystem.

OIL-RICH WATERS

Approximately 600 natural seeps release oil through cracks in the seabed, discharging around one million barrels of oil into the Gulf annually, with salt domes beneath the ocean floor creating faults that provide additional migration pathways for oil and natural gas. These prolific hydrocarbon resources have created an economic powerhouse along the Gulf Coast for two centuries, making it one of the world's busiest waterways, but anthropogenic pollution is only an accident away. Natural seeps also afford scientists the opportunity to ground truth new techniques and study associated processes and organisms for comparison to oil spill impacts.

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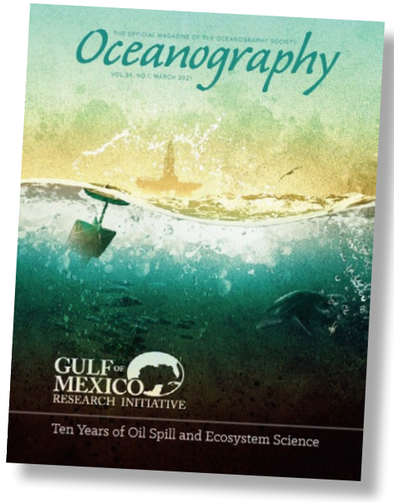
DEEPWATER HORIZON OIL SPILL

On 20th April 2010, the Deepwater Horizon drilling rig lost control of a well as a cement plug installed to temporarily abandon the well hole failed. The gas released caused an enormous underwater explosion that sadly took 11 lives and injured 17 others. But this was only the start of the disaster. Within two days, the rig sank and oil flowed from the broken wellhead, polluting the surrounding water for a further 87 days before the wellhead could be capped. By then, the damage was done, and it would take a decade of research to begin to understand the ongoing impacts of the estimated five million barrels of oil and gas released into the Gulf of Mexico.

GoMRI WAS BORN

In response to the oil spill, GoMRI was initiated on 24th May 2010, eventually bringing together over 4,500 individuals from 17 countries to assess the fate and impact of spilled oil, conduct longer-term independent scientific research, and contribute to policies and frameworks to mitigate such events in the future. The extensive research programme was voluntarily funded by BP PLC long before the well was capped.

Over the past decade, GoMRI has supported the scientific community,



researching the physical distribution and chemical evolution of oil spills and contaminants, biological degradation of oil by microbes, ongoing environmental impacts, ecosystem recovery (both in water and on land), technological advancements to improve response efforts, and public health impacts (both physical and mental). An extensive summary of GoMRI research can be found in the latest issue of *Oceanography* magazine.

OIL DISTRIBUTION PATTERNS

An important starting point was estimating flow rate from the wellhead and eventual oil distribution, a situation complicated by ocean circulation. GoMRI researchers improved understanding of oil movement associated with various ocean currents controlled by wind, temperature, and salinity gradients, such as the Gulf's Loop Current. Water masses (and therefore oil) are mixed both horizontally and vertically. Experiments were conducted using varying pressure and gas levels to investigate oil droplet size distribution, with models revealing how oil plumes behave, especially when influenced by wind- and river-induced currents.

Vertical and horizontal oil plume scales were initially underestimated, causing an additional challenge during clean-up operations. Dispersants (Corexit 9500 and 9527) were sprayed from planes and boats onto surface oil slicks and injected at the broken wellhead 1,500m below the surface. While the scope of this dispersant use was unprecedented, these measures were believed necessary to contain the immediate environmental threat, with subsequent research investigating the impacts of the dispersants themselves on surface-dwelling organisms.

However, with time, oil not cleaned up or removed through natural processes will be buried and further decomposed at the seabed or in coastal sediments through new sediment deposition and longer-term natural processes. Whilst complete burial could take 50 to 60 years, every year of sediment deposition removes pollutants from the Gulf's waters, helping to improve the environment for long-lived biota such as whales, dolphins, and turtles. Though sand-oil aggregates and small tar patties can still be found on beaches when they are exposed by storms, ongoing research into clean-up operations will help to mitigate the future risk to coastal ecosystems.

There is still a significant amount of research to do, but GoMRI's contribution to oil spill science has been invaluable.

MICROBES: SECRET SAVIOURS

As a source of organic matter, oil can be ecologically beneficial or toxic. For oil-degrading microbes within seabed and coastal sediments, oil was a lifeline. Under favourable oxygen, nutrient and temperature levels, a bloom of *Gammaproteobacterial* oil-degrading microbes appeared throughout the Gulf's waters. The bacteria were extremely beneficial during the clean-up process, producing biosurfactants – compounds that assisted in the breakdown of surface oil. Nitrogen-fixing microbes also thrived, using hydrocarbons within oil slicks as a source of energy. A side effect of this bioremediation was the formation of marine oil snow, a phenomenon that transports oil directly to the seabed and can have unfortunate consequences on benthic communities.

BIOLOGY: SOME ON THE BRINK

For the nektonic community (including shrimps, squids, fish, and marine mammals), the story of recovery was mixed and, in some cases, quite detrimental. The surface oil plume and continuous wellhead leak significantly impacted the marine ecosystem, from wetlands to coral reefs. Research vessels sampled the marine community, finding a two-thirds to three-quarters decline in the mesopelagic invertebrate and small fish community from 1,000 to 3,000ft water depths in the years following the disaster; those studies continue.

Commercial fisheries have also been a key research focus as seafood and recreational fishing contribute significantly to the Gulf Coast's economy. By 2018, many of the commercial and recreational fisheries had recovered and landings were back to pre-spill abundance. Some were less fortunate; the Eastern oyster populations in Breton Sound and Barataria Bay suffered billions of deaths from low salinity as river water was released to prevent oil reaching coastal marshes.

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While the environmental consequences of the Deepwater Horizon oil spill were severe, to GoMRI's research team, the human story was a critical piece of the puzzle.

Through GoMRI research, biodegradable drifters have been developed to provide new, detailed observations of small-scale surface currents, permitting scientists to constrain oil transport and monitor oil slicks in real time.

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In Barataria Bay, Louisiana, oil entered coastal marshes, home to dolphins that experienced decreased reproductive success (70% down to 20%), chronic lung damage, and altered hormone responses. Further research revealed organisms throughout the Gulf suffered changes to vision, smell, heart function, and genetics in response to the oil spill.

BREAKTHROUGH CHEMICAL DISCOVERIES

Two-dimensional gas chromatography and ion cyclotron resonance mass spectrometry (experiments that reveal chemical compositions) shed light on identification of specific oil types as well as weathering products from spilled oil. Fish experiments determined the rate that polycyclic aromatic hydrocarbons (chemicals found in oil) pass through the body, informing food safety and organism health. Furthermore, scientists investigated water column hydrocarbon distribution, photo-oxidation's role in changing oil composition at the air–sea interface, and formation of marine snow. Research funded under GoMRI provided new insights into the complex web of biogeochemical processes that influence the fate and impact of the oil and gas released.

HUMAN-HEALTH IMPACTS

With the disaster declared as the only Spill of National Significance in US history, understanding how 15.8 million people living along the Gulf Coast were impacted immediately and longer-term was paramount. Yet documentation of previous spills' health impacts was severely lacking. Physical and mental health impacts of response workers, clean-up crews, and coastal communities were collated, revealing respiratory, heart, skin, and gastrointestinal complications, alongside depression and post-traumatic stress disorder. While the environmental consequences of the Deepwater Horizon oil spill were severe, to GoMRI's research team, the human story was a critical piece of the puzzle.

GoMRI's increased understanding allowed interested stakeholders to develop appropriate legislation and education methods to better prepare for future oil spills.

During GoMRI's Public Health Synthesis discussions, participants reemphasised the important of baseline data, particularly as related to assessing human health consequences. It was recommended that the United States initiate a Community Health Observing System to better track the impact of catastrophic events on humans and communities – designed specifically for disaster-prone areas like the Gulf of Mexico; these types of programmes exist in meteorology and oceanography.

Moreover, GoMRI's research has highlighted the importance of information management. The public were provided with minimal information post-event which led to mistrust. Consequently, despite scientists confirming that seafood contamination risk was minimal, people continued to avoid eating it, damaging the local economy. GoMRI's increased understanding allowed interested stakeholders to develop appropriate legislation and education methods to better prepare for future oil spills.

TECHNOLOGICAL ADVANCEMENTS

Biodegradable drifters have been developed to provide new, detailed observations of small-scale surface currents, permitting scientists to constrain oil transport and monitor oil slicks in real time. Furthermore, deep sea investigations using remotely operated vehicles to record oil and gas bubbles rising from natural seeps could, in time, be used to monitor wellheads and better understand initial blowout conditions.

RESEARCH OF THE FUTURE

GoMRI advocates for data accessibility, with the GoMRI Information and Data Cooperative (GRIIDC) housing all research produced during the ten-year project. Established at the Harte Research Institute for Gulf of Mexico Studies at Texas A&M University-Corpus Christi, GRIIDC facilitates data sharing to promote transparency, maximise resources for collaboration, and ensure scientific independence. Holding an impressive 3,250 data sets (87.7 terabytes of data) from 405 research groups confirms GRIIDC as the premier data repository, portal, and resource for the Gulf region. Outreach activities by GoMRI researchers are encouraged to bridge the gap between academics, operational responders, and the public. If all parties are informed, disasters can be mitigated more swiftly with responses based in scientific understanding. Data sets are accessible through the GRIIDC website (data.gulfresearchinitiative.org/search).

There is still a significant amount of research to do, but GoMRI's contribution to oil spill science has been invaluable. The tragedy has highlighted the importance of preparation when managing offshore resources and through a decade of cutting-edge research, GoMRI has inspired the next generation of oil spill researchers to contribute to the health and safety of our environment and communities.

For more information about GoMRI, visit www.gulfresearchinitiative.org/

Behind the Research

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Detail

Research Objectives
The Gulf of Mexico Research Initiative (GoMRI) aims to investigate the effect of oil spills on the environment and public health.

GoMRI mission
Through a wide range of interdisciplinary and collaborative research, GoMRI established that a programme funded by industry can operate independently and with the highest scientific integrity. The ten-year programme enhanced the understanding of the processes and impacts during and after an oil spill, leading to improved practices in the future.

Funding
BP PLC

References

Special Issue on the Gulf of Mexico Research Initiative: Ten Years of Oil Spill and Ecosystem Science, (2021). *Oceanography,* 34 (1). tos.org/oceanography/issue/volume-34-issue-01

www.gulfresearchinitiative.org/

Dark clouds of smoke produced as oil burns during a controlled fire in the Gulf of Mexico.

A C-130 Hercules sprays Corexit dispersant onto the affected water.

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Capturing heavily oiled young turtles 20 to 40 miles offshore for rehabilitation, 14 June 2010.

The oil seen from space by NASA's Terra satellite on 24 May 2010.