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Editorial: Vulnerability and resilience of marine ecosystems affected by the Deepwater Horizon oil spill

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Editorial on the Research Topic:
Vulnerability and resilience of marine ecosystems affected by the Deepwater Horizon oil spill

While drilling an exploratory oil well in 1,500 meters of water in the northern Gulf of Mexico, the *Deepwater Horizon* mobile platform experienced a blowout on 22 April 2010. The ensuing conflagration killed 11 people and resulted in the sinking of the platform, breaking the riser pipe above the well head. The blowout preventor was ineffective in averting the release of large amounts of crude oil and natural gas. Around the world attention was riveted on videos showing violent discharges over the next 87 days before the blowout could be stopped.

Despite efforts to capture oil, an estimated 750 million liters of oil were released into the water column. For periods of days to months, oil was detected at the surface over 149,000 km^2 of the Gulf of Mexico and 2,113 km of shoreline were oiled (Figure 1). Because of water depths and physical conditions, a substantial amount of oil never reached the sea surface as hydrocarbons were entrained in subsurface plumes in dissolved or suspended form. This entrainment was amended by the injection of large quantities of chemical dispersants directly into the discharge in an attempt to decrease the oil reaching the surface in order to reduce risks to responders and the amount of oil that could come ashore. Petroleum hydrocarbons were deposited on the seabed as microbial-mineral aggregates.

The fate and effects of the *Deepwater Horizon* oil spill have been assessed scientifically more than any previous spill. Extensive measurements were undertaken to track the oil movement and guide responses. State and federal trustee agencies immediately undertook a Natural Resource Damage Assessment (NRDA; Deepwater Horizon Natural Resources Damage Assessment Trustees, 2016) and BP, the responsible party as operator of the well, also commissioned its own assessment activities. When the natural resource damage claims were settled in 2016, BP reimbursed the governmental agencies US$350 million for

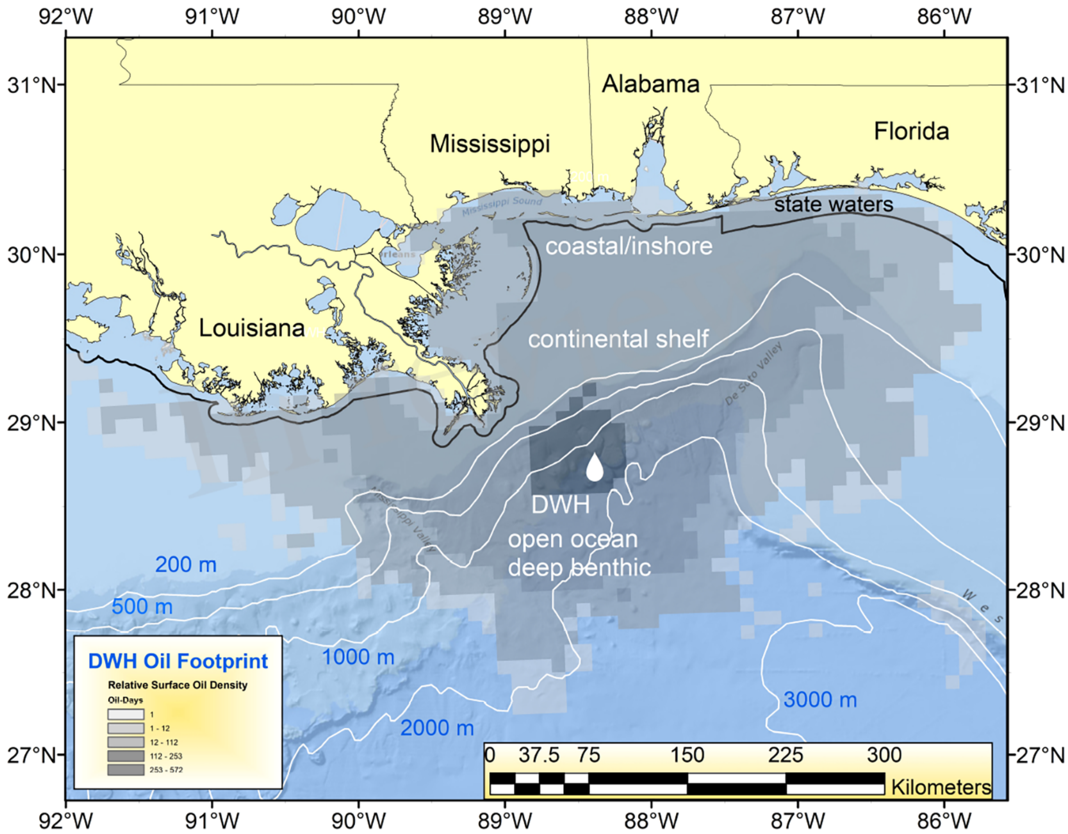

FIGURE 1
The four "eco-types" impacted by the Deepwater Horizon oil spill in 2010 as defined in this Research Topic: coastal/inshore, continental shelf, open ocean and deep benthic. Superimposed is the geographic footprint of surface oil expression (number of days oil was present multiplied by the relative oil thickness). From Murawski, et al. (2023)

assessment costs. One month after the blowout began BP committed US$500 million to study its effects over a ten-year period. The Gulf of Mexico Research Initiative (GoMRI) was created to manage the research as guided by an independent board, mainly through grants to thematic consortia of academic scientists (Zimmerman, et al., 2021). Several thousand papers, book chapters and reports have been published as a result of these collective scientific investigations.

What components and living resources of this vast ecosystem were most affected? How long will it take for them to recover, if ever? This Research Topic seeks to address those questions through five papers that assess the vulnerability and resilience of marine ecosystems affected by the spill. *Vulnerability* was considered as impacts at the species population level due to exposure to oil or countermeasures to mitigate spill impacts. *Resilience* was assessed as the capacity to recover from such impacts.

Because of the location, size and duration of the blowout a wide array of biomes in the northern Gulf of Mexico was affected. These include the pelagic open-ocean waters, the bathyal and abyssal benthos, the continental shelf, and coastal and nearshore environments, including beaches, marshes and mangroves, bays and the Mississippi River delta. Correspondingly, the papers focus on impacts in these four "eco-types": deep benthic (Schwing et al.), coastal and nearshore (Murawski S. et al.), open-ocean pelagic (Sutton et al.), and continental shelf (Patterson et al.). Results are synthesized by Murawski S. et al. in the form of a comparative analysis of the vulnerability and resilience of living marine resources in the eco-types.

The five papers were developed through two workshops that were part of a GoMRI-led synthesis at the conclusion of its 10-year duration. The five papers include 48 co-authors from sixteen universities, seven national or state agencies and one oil-and-gas company. Two-thirds of the co-authors are affiliated with academic institutions and two thirds of those from universities in Florida.

The authors assembled time-series data for populations of species and evaluated their vulnerability and imputed resilience. The authors also noted confounding factors such as other human stressors, fisheries closures, climatic variability, and invasive lion fish. Evidence-based judgement was used in scoring taxa as low, medium, and high for several vulnerability and resilience attributes. Their analysis highlights species with high vulnerability and low resilience such as several cetacean species and cold-water corals.

All of the papers lament difficulties presented by the paucity of quantitative data of sufficient resolution prior to the spill. Nevertheless, the authors contend that their vulnerability-resilience scoring provides guidance on resource allocation for collecting baseline data. Further, because some hydrocarbon contamination remained and the recovery of some species appeared incomplete, they made a plea for continued surveillance of affected populations as deepwater leasing, exploration and oil production continues in the Gulf of Mexico.

Thirteen years after the *Deepwater Horizon* oil spill, the focus of attention has shifted. There has been greater emphasis on improvements in regulations, practices and technology to prevent such blowouts or quickly cap them when they occur (National Academies of Sciences, Engineering and Medicine, 2023). Largely for economic reasons, bids for new leases in the Gulf and exploratory drilling have declined. There is still deepwater drilling, but mainly to develop previously discovered fields. This is not to say that the risk of blowouts has been eliminated, but that circumstances of future oil spills will be different. The vulnerability-resilience scoring approach developed in this Research Topic should, nonetheless, be useful in informing spill control strategies, not only in the Gulf but in other offshore oil and gas producing regions in the world.

Production of natural gas from the Gulf of Mexico has already declined substantially and oil production will decline in the coming decades due to resource depletion, hastened by policies intended to reduce greenhouse gas emissions. Consequences of this wind-down are already apparent on the continental shelf with regard to the disposition of legacy infrastructure and abandoned wells not properly plugged. According to the International Energy Agency (2021), the pathway to the international goal of net-zero emissions excludes approval of any new oil and gas fields beyond those already committed for development as of 2021.

With legal settlements in 2016 with both BP and drillship operator Transocean, the Natural Resource Damage Assessment concluded. GoMRI sunset in 2020. Civil payments as well as criminal plea agreements provided approximately US$13 billion to mitigate or compensate for damages and restore Gulf ecosystems. While these efforts provide opportunity for surveillance of some damaged resources and monitoring to support adaptive management, the expansive baseline and sustained monitoring recommended by the authors is unlikely to be realized. Still, there are many ways in which the insights and concepts developed through this Research Topic can be useful in environmental and natural resource management well into the future.

Author contributions

The authors are editors of this Research Topic. All authors contributed to designing and writing this editorial based on a draft prepared by DB and approved the submitted version.

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Conflict of interest

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