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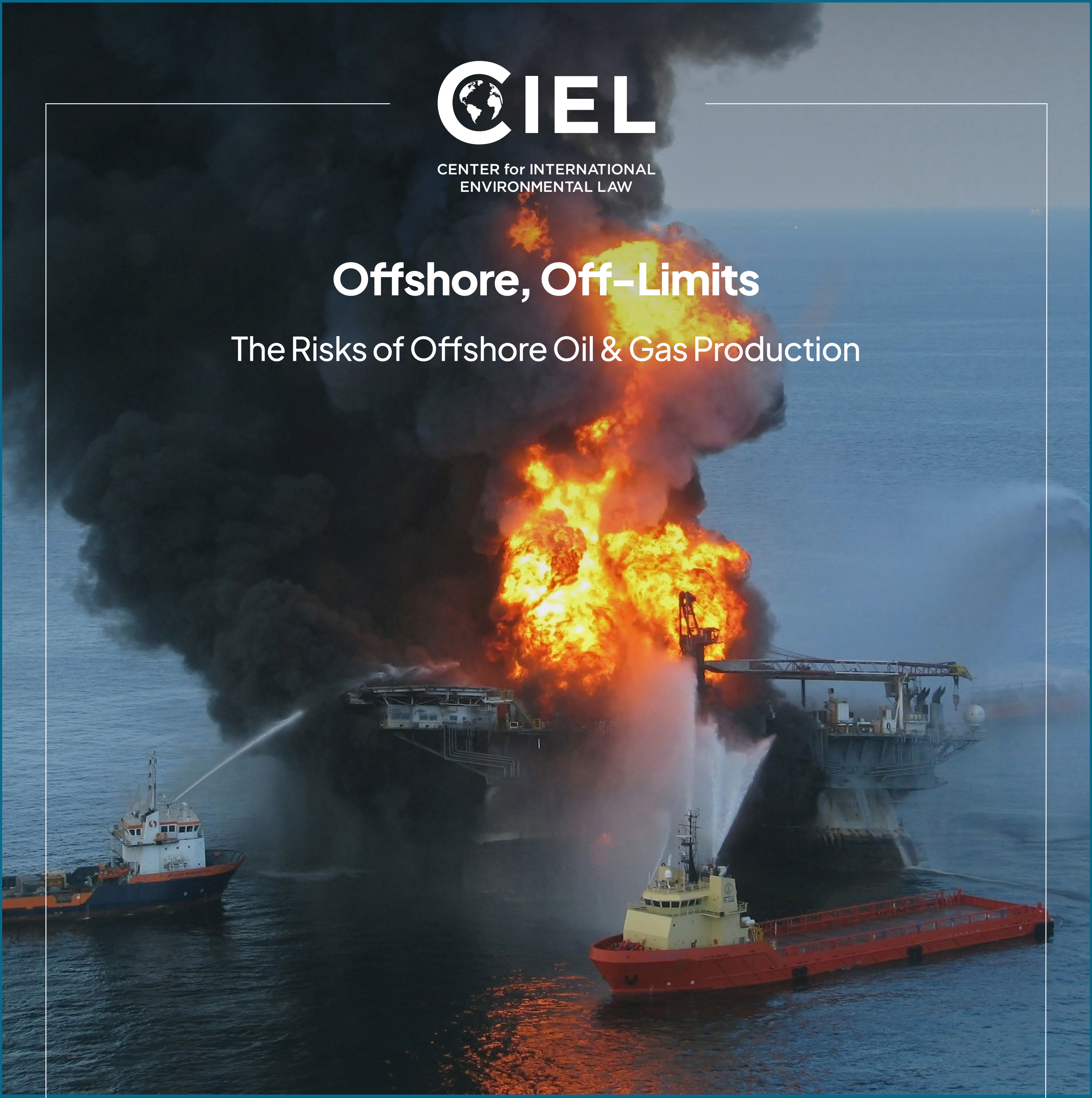
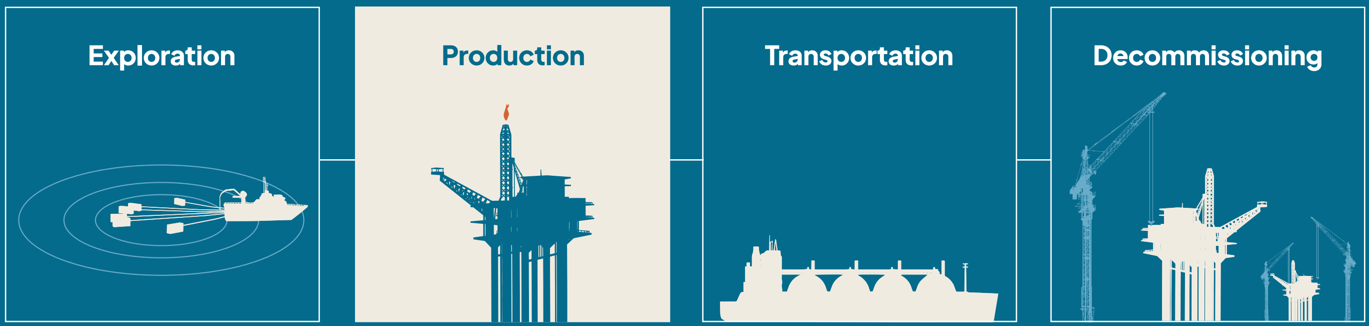
Offshore, Off-Limits

The Risks of Offshore Oil & Gas Production



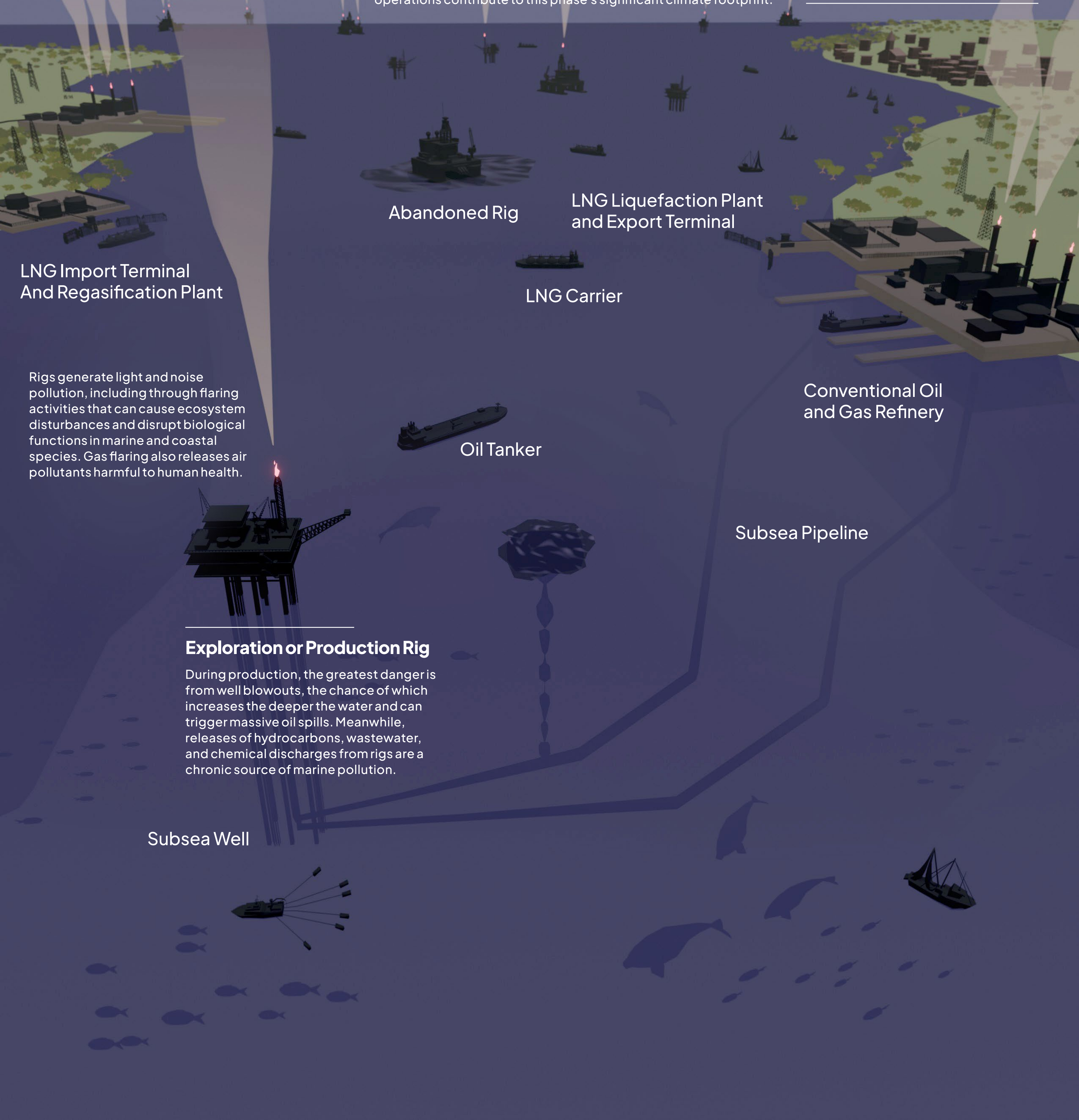


Production

Greenhouse gas emissions stemming from gas flaring, methane leaks from infrastructure, and the energy needed to power operations contribute to this phase's significant climate footprint.

Onshore Fracking Fields

The extraction of fossil gas that is converted to LNG and transported across oceans occurs both onshore and offshore.



Rigs generate light and noise pollution, including through flaring activities that can cause ecosystem disturbances and disrupt biological functions in marine and coastal species. Gas flaring also releases air pollutants harmful to human health.

Exploration or Production Rig

During production, the greatest danger is from well blowouts, the chance of which increases the deeper the water and can trigger massive oil spills. Meanwhile, releases of hydrocarbons, wastewater, and chemical discharges from rigs are a chronic source of marine pollution.

Offshore oil and gas activity poses myriad threats to the environment and human rights across its life cycle, from exploration and production to transportation and decommissioning. *Offshore, Off-Limits* examines many of the relevant risks and impacts at each of these phases. This brief in the series focuses on the risks and impacts associated with offshore oil and gas production.

Key Takeaways

- Offshore oil and gas production platforms have outsized yet largely underreported climate footprints due to emissions from gas flaring, methane leaks from offshore infrastructure, and the massive amounts of energy needed to power production operations.
- The greatest danger associated with offshore oil and gas production is the significant potential for well blowouts, which can trigger massive and ecologically devastating oil spills, injure and threaten the lives of platform workers, and unleash dangerous air quality impacts.
- The deeper the well, the greater the risk of large-scale disaster from a blowout and spill.
- Blowouts and oil spills can have devastating, long-term repercussions for affected communities' economies, livelihoods, and mental and physical health.
- Certain oil spill practices are largely ineffective and can exacerbate environmental harm, underlining the need to end offshore drilling and its associated risks.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What Is Offshore Production?

Producing oil and gas in the oceans involves pumping hydrocarbon deposits from deep under the seabed, separating their liquid and gaseous components, and preparing them for transport to end users. Many of the dangers of offshore oil and gas operations with the most potential for large-scale and/or long-term harm are associated with production phase activities.[1] Drilling for and processing oil and gas at sea pose the risk of accidental spills, uncontrolled releases of toxic fluids and planet-warming gases from wells, and routine discharge of wastes into the marine environment. Moreover, the process of extracting oil and gas from subsea wells consumes enormous amounts of energy, leading to significant greenhouse gas (GHG) emissions and poor air quality. The impacts of offshore production pose numerous risks to the health and livelihoods of local communities, marine life, and coastal ecosystems far and wide, as well as to the global climate.

How Is Offshore Production Carried Out?

Installation of Production Infrastructure

The production phase begins with the installation of drilling platforms and pipelines, which are anchored to the seafloor. Based on the water depths where drilling occurs, the production facilities may be fixed, floating, or subsea.[2] Larger, above-water platforms — generally used in deep- and ultra-deepwater — often employ more than a hundred workers to keep them running.[3] The risk of explosions and fires, detailed below, makes these platforms extremely dangerous.

In areas where it is challenging or not economically viable to carry out production activities on above-water platforms, offshore operators will rely on subsea production systems.[4] In those situations, rather than building a production platform for an individual well, operators transport oil, water, and gas for many miles from multiple wells through a network of pipelines to distant processing facilities. Marine oil and gas pipelines are laid by ships, which move down the pipeline route, welding together sections of steel pipe.[5] During this process, cables and anchors are dragged along the seabed, disturbing local biota.[6]

Recovery

Extracting oil and gas from underground reservoirs involves using pumps, gas valves, and motors to drive the hydrocarbon mixture to the surface. When the pressure in the reservoir drops, operators often resort to enhanced oil recovery (EOR) techniques, such as injecting liquid or gas underground to bring more oil to the surface.[7] The most common EOR technique used offshore involves injecting water produced from the initial oil separation process back into the well — a method known as waterflooding.[8] This produced water constitutes the largest volume of waste associated with offshore oil and gas production activities.[9] It contains a litany of toxic substances, including dispersed hydrocarbons, heavy metals, naturally occurring radioactive materials (NORMs), production chemicals, and dissolved gases.[10]

Processing and Export

Once at the surface, the hydrocarbon (oil and gas) mixture is either received by a floating production, storage, and offloading (FPSO) unit, transported to an FPSO by short infield pipelines, or transported directly onshore for processing via pipeline or tanker.[11] At an onshore refinery, the oil and gas are converted to commodities like diesel, petrol, and residential fuels.

Offshore oil and gas processing facilities account for the highest rate of critical accidents in the petroleum industry.[12] These incidents are very difficult to control because processing facilities use highly flammable, toxic chemicals at extreme temperatures and pressures. The risks associated with the various modes of transporting extracted oil and gas from offshore production sites to onshore facilities are detailed in the Transportation brief.

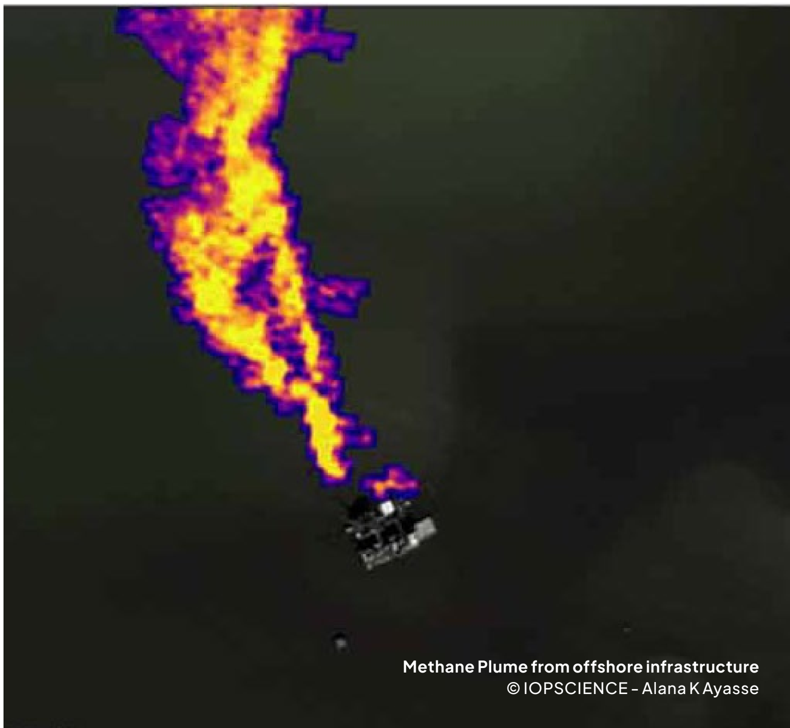
What Are the Risks Posed by Offshore Production?

Oil spills and blowouts resulting from equipment failure, human error when offloading and filling tanks, cleaning operations, and poor handling of wastes and chemicals put oceans — and the ecosystems, communities, and global climate that depend on them — under substantial stress. Gas can also pose hazards during production, from explosions to leakage of planet-warming methane. Hydrocarbon, wastewater, and chemical discharges from producing platforms add to chronic marine pollution, and additional direct physical impacts occur as subsea infrastructure is installed. The following sections detail several of the greatest risks during production: well blowouts, oil spills, contaminated discharges, greenhouse gas emissions, and other forms of air, noise, and light pollution.

Climate Risks

Offshore oil and gas platforms, which account for 30 percent of global oil and gas production,[13] have outsized climate footprints. The process of extracting oil and gas deposits from subsea reserves is energy-intensive. It releases enormous quantities of greenhouse gases, including carbon dioxide (CO_2), methane (CH_4), non-methane volatile organic carbon (VOC), nitrogen oxides (NO_x), and sulfur oxides (SO_x).[14] These emissions are attributable to the combustion of fossil fuels needed to power the operations, as well as leakages from wells and the venting and flaring activities that routinely occur during production.[15] The treatment of produced water on oil and gas platforms, the injection of polymers, and the reinjection of produced water into the reservoir require even more energy, thus increasing the emissions released into the atmosphere.[16]

The high concentrations of GHGs emitted during oil and gas production do not merely contribute to anthropogenic climate change. They also lead to coastal erosion, warming oceans, and other destructive ecological impacts, as well as contribute to the degradation of the marine ecosystem through ocean acidification. This is caused by the deposition of excess quantities of CO_2 into the ocean, which results in mass coral bleaching and other adverse impacts.



Methane Plume from offshore infrastructure
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Existing data likely undercount total emissions from the production phase of offshore oil and gas, in part due to the technological and logistical challenges of monitoring emissions at sea. A study by Carbon Mapper utilizing remote sensing technology revealed that shallow-water platforms in the Gulf of Mexico have more persistent and significantly higher methane loss rates than typical onshore production sites (23 to 66 percent compared to 3.3 to 3.7 percent) and thus disproportionately contribute to climate change.[17] Methane — a by-product of oil and gas production[18] — can trap 86 times more heat than the same amount of CO_2 over a 20-year period and is, therefore, a highly potent greenhouse gas.[19] According to findings from the study, many shallow-water platforms could be super-emitters of methane.[20]

Another pernicious source of emissions during production is gas flaring, the on-site burning of natural gas that is too uneconomical to sell and costly to store and dispose of safely. A common industry practice, gas flaring releases a potent planet-warming mix of methane, CO_2, and black carbon, contributing around 1 percent of anthropogenic CO_2 emissions annually.[21]

Gas flaring emissions from the offshore oil and gas industry have gone largely unreported. An investigation published in 2022 revealed that flaring in dozens of oil fields operated by some of the world's largest fossil fuel companies — British Petroleum (BP), Eni, ExxonMobil, Chevron, and Shell — had emitted 20 million metric tons of CO_2 equivalent in 2021, comparable to the annual GHG emissions of 4.4 million cars.[22] As oil and gas operations move to increasingly remote locations at sea and ever-deeper waters, more emissions from flaring operations may go undetected, with little to no accountability.

Stopping further offshore expansion is critical if we are to avoid the worst impacts of rising global temperatures. The best available science has made clear that it is not possible to limit average global temperature rise of 1.5˚C or above — which is necessary to avoid serious, irreversible harm to oceans, the climate system, and human rights[23] — without steep and rapid reductions in GHG emissions possible only through the phaseout of fossil fuels.[24] Yet according to the UN Environment Programme's 2023 Production Gap Report, governments currently plan to produce far more oil and gas than is consistent with a 1.5˚C pathway — 29 percent and 82 percent higher, respectively.[25] Ongoing and planned offshore projects, if allowed to advance, will drive the world faster to climate catastrophe. From drilling to downstream fossil fuel burning and use, ExxonMobil's oil and gas operations off Guyana's coast are slated to release 125 million metric tons of CO_2 into the atmosphere every year from 2025 to 2040 — roughly equivalent to the climate footprint of 15 large coal-fired power plants. This is on top of the additional tens of millions of tons of GHG emissions it will produce through gas flaring.[26] In the North Sea, licensing new offshore exploration and developing already-licensed oil and gas fields could unleash 10.3 billion metric tons of CO_2, which is 25 times the UK's annual emissions at current levels.[27] Conversely, studies show that globally halting the expansion of offshore drilling and phasing down production from existing subsea wells could cut emissions by 6.3 billion metric tons of CO_2 equivalent per year by 2050, which is around 13 percent of the total emissions reductions needed to keep warming under 1.5˚C.[28]

Stopping new offshore development projects from moving forward while shutting down existing production is thus essential to ensuring a safe climate and livable planet. In light of this reality, legal challenges to new offshore oil and gas projects increasingly highlight the incompatibility of States' climate commitments with the authorization, financing, and support of these projects, given their massive climate impacts. In a decision from January 2024, a court in Norway invalidated the permits for three new oil and gas fields in the North Sea, finding that the Breidablikk, Tyrving, and Yggdrasil fields were approved illegally. In reaching that conclusion, the Oslo District Court cited the Norwegian government's failure to assess the global climate impacts that would stem from the downstream use of the oil and gas produced from the fields and exported for consumption abroad.[29] Similarly, in June 2024, the UK's highest court ruled that planning applications for new oil and gas extraction projects must consider the environmental impact of emissions generated not only from drilling but also from the burning of fossil fuels.[30] The ruling casts doubt on the future of the UK government's plans to develop large offshore oil fields in the North Sea.[31] The Norway and UK cases are just two of a growing list of legal challenges that have leveraged climate arguments to protect oceans — and the planet — from the many dangers posed by the offshore oil and gas industry's expansion.[32]

Environmental and Biodiversity Risks

Well Blowouts

By far, the greatest danger associated with offshore oil and gas production is the significant potential for well blowouts, which can have devastating impacts on rig workers and the environment. A blowout is an uncontrolled release of crude oil, fossil gas, and/or other fluids from a well caused by a sudden surge in pressure.[33] Though offshore facilities are normally equipped with blowout preventers designed to seal off wells and avoid such emergencies, human error and mechanical failings are not uncommon. The 2009 Montara blowout and accompanying oil spill off the coast of Western Australia, discussed below, was reportedly the result of technical failures and a series of human errors.[34] However, blowouts are not unique to the production phase, and they can also occur during exploratory drilling, as was the case when a system failure at BP's Macondo well led to the Deepwater Horizon disaster. However, because the ecological and human rights impacts of blowouts and accompanying oil spills are similar across the four phases, they are discussed, along with lessons drawn from Deepwater Horizon, below.

Blowouts of oil production wells can also generate massive spills capable of inflicting widespread and lasting damage to entire ecosystems, economies, and communities. As discussed below, when drilling takes place in deep ocean waters with uncontrolled currents and volatile conditions, the possibility of a spill, the danger and difficulty stopping it, and the risks to surrounding life and the environment are magnified.

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Methane released by ruptured wells has been observed to contribute to oxygen-depleted hypoxic zones that cannot support marine life. Such "dead zones" were observed in the aftermath of the BP Deepwater Horizon spill, which resulted in "astonishingly high" concentrations of methane in areas of the Gulf of Mexico — in some cases 100,000 times normal levels.[35] While there may be multiple causes or contributing factors to dead zones, including agricultural runoff,[36] some scientists speculate that this phenomenon can occur when the accumulation of methane results in increased populations of microbes that break down the methane but also deplete oxygen levels in the process, driving out other marine life.[37] While more research is needed to establish the relationship between offshore methane emissions and hypoxic marine conditions, there is reason to presume that leaking wells can potentially increase the risk of ocean deoxygenation and the myriad risks it poses to marine life.[38]

The deeper the well, the greater the risk of large-scale disaster in the event of a blowout. According to one study, for every 100 feet (ft) deeper a well is drilled, "the likelihood of a company self-reported incident like a spill or an injury increased by more than 8 percent."[39] Before disaster struck, BP's Deepwater Horizon was in the process of drilling what was one of the deepest offshore oil and gas wells ever drilled, the Tiber well, in water over 4,000 ft deep and with a wellbore 35,000 ft below the seafloor.[40] When the nearby ultra-deepwater exploratory well Macondo blew out, it produced the largest offshore spill in the history of the United States,[41] releasing 3.19 million barrels of crude oil (134 million gallons) across sensitive marine ecosystems and polluting more than 57,500 square miles (m^2) of the Gulf of Mexico.[42] Today, there are ultra-deepwater drilling rigs capable of drilling down to 40,000 ft, which is 11,000 ft deeper than Mount Everest is tall.[43]

Even spills from blowouts in shallower waters are challenging to stop. The 2009 Montara blowout occurred in relatively shallow waters at just over 70 m (238 ft) in the East Timor Sea. Yet, it still took *ten weeks* for personnel to control the spill.[44] In the meantime, the blowout released 80,000 gallons of oil into the sea *every day*, contaminating Indonesian waters as far as 150 nautical miles (240 km away).[45] Such spills' social, economic, and environmental consequences can be devastating.

Oil spills in shallow waters are also especially harmful to sensitive habitats such as coral reefs, mangroves, and seagrass meadows. For instance, three decades after a 1986 oil spill in Bahia de las Minas, Panama, coral reefs still have not returned to their pre-oil spill conditions. This is largely due to several factors, including recurring human-induced perturbations such as chronic oil pollution from frequent ship traffic in the area and the activities of local refineries, as well as climate change.[46] Currents can also bring contaminants from deep-water installations to shallower waters, such as what was experienced in the Chandeleur Islands, Louisiana, in the aftermath of the Deepwater Horizon disaster.[47]

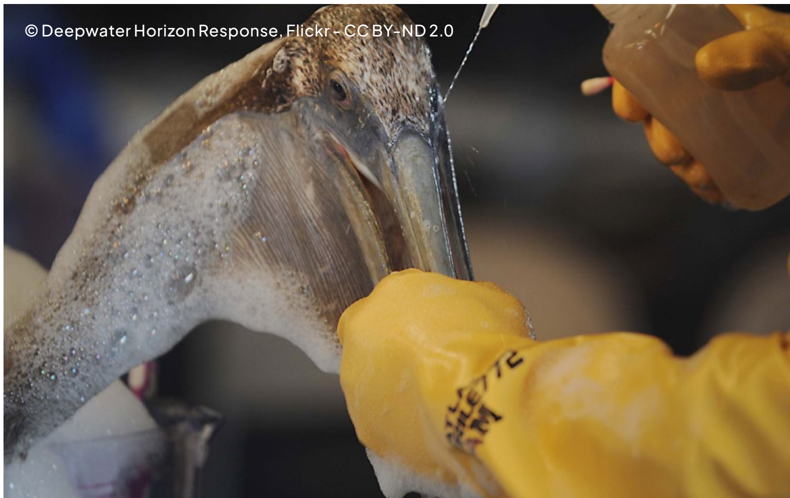
Oil Spills

Where there is oil production, there are oil spills. Despite improved safety regulations in some countries and technological advancements in recent decades, offshore spill incidents during production and other phases have increased over the last thirty years.[48] Spills vary in size, severity, frequency, and duration, but they are always harmful to the environment. Spills can stem from transport vessels, pipelines, refineries, and storage facilities, but the risk of larger and, therefore, more severe oil spills is higher from drilling as the potential amount of oil that could be released is far greater.[49]

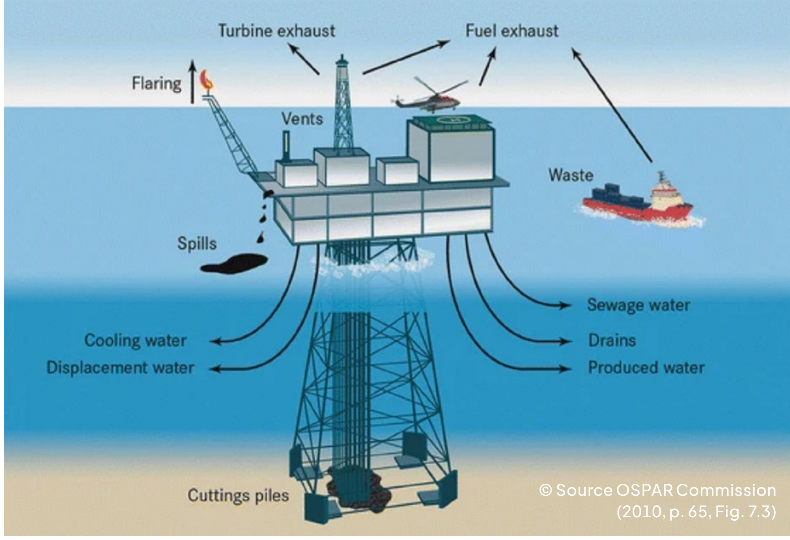
The aggregate environmental consequences of even routine, smaller-scale oil spills should not be minimized. Leaked oil, whatever its source, can enter marine and coastal ecosystems in a number of ways, each presenting grave risks to health and life:

- **Surface slicks** endanger wildlife on the sea surface — such as sea birds, dolphins, sea turtles, and whales.[50] Wind and currents can cause slicks to spread further and contaminate an increasingly larger geographic area.[51]
- **Dissolved oil** can harm plankton and larval stages of fish and invertebrates that live in the upper water column. In fish and invertebrates specifically, the toxic components of oil can damage organs, gills, and reproductive systems,[52] endangering marine food webs and, for local human populations, their food security and livelihoods.
- **Shoreline oiling** not only creates an eyesore and a mess that is difficult to clean up and financially devastating for tourism,[53] but it can also smother beaches, mangroves, wetlands, estuaries, and other coastal ecosystems that are important habitats for fish and invertebrates during their early developmental stages.[54] Birds and mammals that come into contact with the contaminated shorelines and feed on oiled animals and vegetation face serious health risks.[55]

Some oil spill cleanup practices commonly employed by operators can be largely ineffective and exacerbate environmental harm, underlining



the need to end offshore drilling and its associated risks. Even with the best available technologies — which have undergone little improvement since the 1960s — marine cleanup efforts recover only a small fraction of oil spilled.[56] In the aftermath of the Deepwater Horizon disaster, only about 25 percent of the 200 million gallons of crude oil spilled in the Gulf of Mexico could be recovered by skimming the oil, siphoning it at the wellhead, and burning it.[57] Most of the oil ended up on the bottom of the ocean floor, evaporated into the atmosphere, dissolved into the water, polluted beaches, or remained on or just below the water's surface.[58] Ironically, certain chemicals used in oil spill response plans can actually make oil spills three- to 52 times more toxic, depending on the marine organism.[59] Chemical dispersants also do not actually remove oil from the water; they merely break it down and displace it into the water column, where it remains toxic to marine life.



© Source OSPAR Commission (2010, p. 65, Fig. 7.3)

Operational Contamination

The release of wastewater from offshore oil and gas platforms is a continuous source of contaminants to marine ecosystems.[60] According to known estimates, over 700 million metric tons of produced water is discharged annually into the marine environment worldwide.[61] As noted before, produced water can contain compounds that are hazardous chemicals and known carcinogens, such as polycyclic aromatic hydrocarbons (PAHs). PAHs can lethally affect fish species in several ways, inducing DNA damage, cardiac function defects, embryotoxicity (which interferes with normal growth, homeostasis, and development of a fetus), and oxidative stress, which reduces the ability of a species to detoxify readily.[62] Produced water also contains alkylphenols (AP), endocrine disruptors that can prompt abnormal hormonal changes in fish.[63]

The impacts of discharging contaminated water in surrounding ecosystems are most evident in bottom habitats near the seabed, where organisms can become smothered by oil and other contaminants. Injecting produced water back into the ocean and flooding the well with polymers for EOR can alter the density, biomass, and diversity of various marine organism communities, including corals.[64] This can have damaging effects on the marine food web. Declines in the populations of the most vulnerable benthic species (those that live at the bottom of the sea), particularly smaller crustaceans, have been detected at distances of up to 10 km from production platforms, in part due to the discharge of produced water.[65]

Noise and Light Pollution

The significant light and noise pollution from offshore rigs can cause ecosystem disturbances and harmful behavioral and physiological changes in marine and coastal wildlife. Gas flaring contributes to light pollution that disturbs fish, turtles, birds, and other wildlife,[66] impacting marine food webs on which coastal populations depend. For example, certain species of seabirds, such as storm petrels, can be attracted to offshore production platforms, drilling rigs, and support vessels and become disoriented by their attraction to light sources.[67] This attraction can be lethal due to flames from gas flares, collision with infrastructure,[68] and exposure to oil. Such episodic events are known to cause the death of hundreds or even thousands of birds.[69] The hammering sounds of drills also contribute to noise pollution detectable by various taxa of marine organisms,[70] which in turn can disturb physiological processes, cause behavioral disruptions, affect mating patterns, and lead to tissue damage, physical injury, and even death in a wide range of species.[71]

The Lasting Legacy of a Blowout

An offshore blowout and accompanying spill can leave a legacy of harm and precipitate legal challenges years later when the long-term implications for surrounding ecosystems and communities become evident. Although BP's Deepwater Horizon catastrophe has become synonymous with the dangers of offshore drilling, the 2009 Montara spill — which occurred only one year prior — is considered one of Australia's worst environmental disasters. The blowout occurred off the northern coast of Western Australia at the Montara Wellhead Platform, which was operated by an Australian subsidiary of Thailand's PTT Exploration and Production (PTTEP), spilling an estimated 30,000 barrels into the Timor Sea over 47 days. The resulting slick covered an estimated 90,000 km^2 — an area larger than Tasmania — devastating the fishing grounds and seaweed crops on which thousands depended for income and their way of life.[72]

In 2016, 8 years after the disaster, 15,000 Indonesian seaweed farmers filed a class action suit against PTTEP Australia, claiming negligence under common law and seeking compensation for lost livelihoods and opportunities.[73] Notably, the plaintiffs alleged that not only the oil spill but the toxic chemical dispersants used for cleanup efforts ruined their seaweed crops. In 2021, the Federal Court of Australia found that PTTEP Australia had breached its duty of care to the farmers by failing to properly seal the well, creating a "very high risk of blowout," and ordered the company to pay lead plaintiff Daniel Sanda around $17,500 for lost income.[74] PTTEP appealed the decision and, as of early 2022, Sanda had not received any payments — and thousands of other plaintiffs were still awaiting compensation.[75] Then, in November 2022, PTTEP agreed to pay $127.4 million in compensation in an out-of-court settlement, a significant step forward in the seaweed farmers' long and challenging fight for justice.[76]

Health, Livelihood, and Cultural Risks

Blowouts are extremely dangerous and endanger life and limb. The violent explosions that accompany blowouts can cause immediate and severe damage to offshore infrastructure and inflict life-threatening injuries and death.[77] Blowouts can also result in raging fires fueled by releasing explosive gases that accumulate and form highly flammable and toxic clouds,[78] with deadly and costly results. The 1988 Piper Alpha platform explosion offshore the UK, for instance, killed 167 platform workers, injuring and traumatizing many more.[79] Considered the world's deadliest offshore oil disaster, the incident affected 10 percent of UK oil production and led to financial losses of an estimated GBP 2 billion (the equivalent of $5 billion today).[80] Decades later, in 2010, the catastrophic blowout and resulting fire that destroyed BP's Deepwater Horizon rig in the Gulf of Mexico killed 11 workers and injured 17 others.[81] While serious design flaws and systems failures contributed to the Deepwater Horizon and Piper Alpha disasters, as the Institution for Chemical Engineers acknowledges, "even perfectly engineered 'hardware' can always be operated incorrectly."[82]

Blowouts can also present air quality issues and consequent health implications for on-site personnel and downwind coastal populations.[83] Research by the National Oceanic and Atmospheric Administration (NOAA) revealed that the quantity of air pollutants in the atmospheric plume generated by the Deepwater Horizon blowout was comparable to that of a large city.[84]

Exposure to crude oil from blowout-related spills can be dangerous to human health. People can become exposed to oil-based toxins that remain in the water and/or collect in the tissues of marine life and other species, eventually making their way up the food chain in progressively larger quantities. For instance, chemical components of crude oil (PAHs) — which can persist in the environment and animal tissues for months or even years — have been linked to cancers of the skin, lungs, bladder, and gastrointestinal system.[85]

Oil spills jeopardize coastal livelihoods. The BP Deepwater Horizon disaster demonstrated just how devastating a blowout and oil spill can be for the health of a region dependent on fisheries and tourism. Studies estimated that the accident led to a loss of $8.7 billion and over 20,000 jobs.[86] But such risks are not unique to the Gulf of Mexico. If a similar event were to happen in the Caribbean Sea — which in recent years has become a hotspot for offshore development — the livelihood impacts could be even more severe. The Caribbean is more dependent on tourism for income than any region in the world, with the sector contributing more than $60 billion to the region's gross domestic product (GDP) in 2022.[87] Another economically significant industry, fisheries, employs over 400,000 people in the Caribbean directly and indirectly (per 2019 figures).[88] In fact, according to environmental groups, in Trinidad alone, at least 50,000 fisherfolk would be affected by a large-scale oil spill.[89] In ocean-dependent regions such as the Caribbean, tourism and fisheries rely on healthy coral reefs and coastal areas. An offshore oil spill could jeopardize these sectors. Moreover, the economic hardships associated with oil spills can compound the mental health impacts that such disasters can have on affected communities, causing lasting harm.[90]

On top of climate impacts, emissions from gas flaring can also cause a number of serious health problems. The practice releases harmful pollutants such as particulate matter (PM2.5), ozone, nitrogen dioxide (NO_2), and benzo[a]pyrene (BaP), which have been linked to strokes, cancer, asthma, and heart disease at high concentrations and prolonged exposure.[91] Moreover, black carbon (also called soot) can impede lung function and cause respiratory disease, heart disease, and stroke.[92] In the oil-producing regions of Nigeria, regular gas flaring has resulted in debilitating and deadly diseases among the local populations, including bronchitis, asthma, cancer, and blood disorders.[93] In the US, in 2019 alone, exposure to black carbon from gas flaring caused dozens of premature deaths.[94]

Conclusion

From the dangers of a well blowout or oil spill to massive and underreported emissions from leaks, venting, and flaring, offshore oil and gas production threatens oceans, ecosystems, and the communities and climate that depend on them. Where there is oil production, there are oil spills. The transboundary reach and lasting impacts of spills on marine life, coastal ecosystems, and dependent populations mean that a single project can put many countries at risk. Response measures remain largely ineffective and pose their own environmental risks, including the toxicity of chemical dispersants. Given the outsized climate footprint of offshore operations, which account for nearly one-third of global oil and gas production, stopping offshore expansion and accelerating the phaseout of existing operations is critical to avoiding catastrophic warming. The risks and impacts of other phases of offshore oil and gas activity are explored further in the other briefs in the *Offshore, Off-Limits* series, which can be found on CIEL's website.

Endnotes

1. United Nations Environment Programme (UNEP), *Harmful Marine Extractives: Understanding the Risks and Impacts of Financing Non-renewable Extractive Industries*, 2022, 26, https://www.unepfi.org/wordpress/wp-content/uploads/2022/04/Harmful-Marine-Ex-tra-ctives_Offshore-Oil-Gas.pdf.
2. "The Basics of Offshore Oil & Gas," National Ocean Industries Association, accessed June 5, 2024, https://www.noia.org/basics-offshore-oil-gas/.
3. "The Largest Oil Rigs in the World," *Discovery UK*, July 25, 2023, https://www.discoveryuk.com/building-big/the-largest-oil-rigs-in-the-world/.
4. A.S. Cheliyan and S.K. Bhattacharyya, "Fuzzy Fault Tree Analysis of Oil and Gas Leakage in Subsea Production Systems." *Journal of Ocean Engineering and Science* 3, no. 1 (March 1, 2018): 38, https://doi.org/10.1016/j.joes.2017.11.005.
5. UK Department of Trade and Industry (UK DTI), "An Overview of Offshore Oil and Gas Exploration and Production Activities," August 2001, 18, https://assets.publishing.service.gov.uk/media/5a7a2ac2e5274a319e77853e/SD_SEA2EandP.pdf.
6. Erik E. Cordes et al., "Environmental Impacts of the Deep-Water Oil and Gas Industry: A Review to Guide Management Strategies," *Frontiers in Environmental Science* 4 (September 15, 2016): 9, https://doi.org/10.3389/fenvs.2016.00058.
7. Mehu Vora, Steinar Sanni, and Roger Flage, "An Environmental Risk Assessment Framework for Enhanced Oil Recovery Solutions from Offshore Oil and Gas Industry," *Environmental Impact Assessment Review* 88 (May 1, 2021): 1, https://doi.org/10.1016/j.eiar.2020.106512.
8. Wanli Kang et al., "A Dynamic Scale Location Monitor Method to Predict Oilfield Blockage During Water Flooding," *Journal of Petroleum Science and Engineering* 191 (August 1, 2020): 1, https://doi.org/10.1016/j.petrol.2020.107168. For more discussion on the risks associated with offshore carbon capture and storage (CCS) in the context of enhanced oil recovery (EOR), see CIEL, *Deep Trouble: The Risks of Offshore Carbon Capture and Storage*, November 16, 2024, https://www.ciel.org/reports/deep-trouble-the-risks-of-offshore-carbon-capture-and-storage-november-2023/.
9. Mohammad A. Al-Ghouti, et al., "Produced Water Characteristics, Treatment and Reuse: A Review." *Journal of Water Process Engineering* 28 (April 2019): 222, https://doi.org/10.1016/j.jwpe.2019.02.001; Bureau of Ocean Energy Management, "Questions, Answers, and Related Resources," last accessed June 6, 2024, https://www.boem.gov/environment/environmental-assessment/questions-answers-and-related-resources; Donald C. Gordon et al., "Understanding the Impacts of Oil and Gas Activities on the Marine Environment," in *Voyage of Discovery: Fifty Years of Marine Research at Canada's Bedford Institute of Oceanography*, ed. D.N. Nettleship, D.C. Gordon, C.F.M. Lewis, and MP Latremouille (Dartmouth, Nova Scotia, Canada: BIO-Oceans Association, Bedford Institute of Oceanography, 2014), 372, https://www.researchgate.net/publication/305316486.
10. Torgeir Bakke, Jarle Klungsøyr, and Steinar Sanni, "Environmental Impacts of Produced Water and Drilling Waste Discharges from the Norwegian Offshore Petroleum Industry," *Marine Environmental Research* 92 (December 2013): 155, https://doi.org/10.1016/j.marenvres.2013.09.012.
11. UK DTI, *An Overview of Offshore Oil and Gas Exploration and Production Activities*, 16, 18; Manuel R. Suarez, "More Gas Processes Are Heading Offshore," *Offshore*, October 16, 2014, https://www.offshore-mag.com/field-development/article/16757170/more-gas-processes-are-heading-offshore.
12. Jyoti Bhandari et al., "Dynamic Risk-based Maintenance for Offshore Processing Facility," *Process Safety Progress* 35, no. 4 (May 6, 2016): 400, https://doi.org/10.1002/prs.11829.
13. Alana K. Ayasse, et al., "Methane Remote Sensing and Emission Quantification of Offshore Shallow Water Oil and Gas Platforms in the Gulf of Mexico." *Environmental Research Letters* 17, no. 8 (August 11, 2022): 1, http://doi.org/10.1088/1748-9326/ac8566,
14. Mehu, Sanni, and Flage, "An Environmental Risk Assessment Framework for Enhanced Oil Recovery Solutions from Offshore Oil and Gas Industry," 6.
15. World Bank Group, *Environmental, Health, and Safety Guidelines for Offshore Oil and Gas Development*, June 5, 2015, 2, 3–5, https://www.ifc.org/content/dam/ifc/doc/mgrt/final-jun-2015-offshore-oil-and-gas-ehs-guideline.pdf.
16. Mehu, Sanni, and Flage, "An Environmental Risk Assessment Framework for Enhanced Oil Recovery Solutions from Offshore Oil and Gas Industry," 6–7.
17. Ayasse et al., "Methane Remote Sensing and Emission Quantification," 9; Nichola Groom, "Methane Emissions from US Shallow Offshore Platforms Exceed Those on Land, Study Finds," Reuters, August 11, 2022, https://www.reuters.com/business/environment/methane-emissions-us-shallow-offshore-platforms-exceed-those-land-study-finds-2022-08-11/.
18. Ramón A. Alvarez, "Assessment of Methane Emissions from the US Oil and Gas Supply Chain." *Science* 361, no. 6398 (June 21, 2018), https://www.science.org/doi/full/10.1126/science.aar7204.
19. "Methane," Climate and Clean Air Coalition, last accessed June 5, 2024, https://www.ccacoalition.org/short-lived-climate-pollutants/methane.
20. Ayasse et al., "Methane Remote Sensing and Emission Quantification, 5.
21. Gunnar W. Schade, "Routine Gas Flaring Is Wasteful, Polluting and Under-measured," DeSmog, August 18, 2020, https://www.desmog.com/2020/08/18/routine-natural-gas-flaring-wasteful-polluting-under-measured/.
22. Esme Stallard, Owen Pinnell, and Jess Kelly, "Revealed: Huge Gas Flaring Emissions Bever Reported," BBC, September 28, 2022, https://www.bbc.com/news/science-environment-62917498.
23. Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2022: Impacts, Adaptation and Vulnerability. Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. H.-O. Pörtner et al. (Cambridge, UK and New York, NY, USA: Cambridge University Press, 2022), https://doi.org/10.1017/9781009325844, B.6, B.6.1, Technical Summary, C.12.3, TS C.13, and TS C.13.1; "warming of 1.5˚C is not considered 'safe' for most nations, communities, ecosystems and sectors and poses significant risks to natural and human systems as compared to the current warming of 1˚C (high confidence)", IPCC, *Global Warming of 1.5˚C, An IPCC Special Report on the Impacts of Global Warming of 1.5˚C Above Pre-industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty*, ed. V Masson-Delmotte et al. (Cambridge, UK and New York, NY, USA: Cambridge University Press, 2019), Technical Summary, 4, https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_High_Res.pdf.
24. International Energy Agency (IEA), *Net Zero Roadmap: A Global Pathway to Keep the 1.5C Goal in Reach*, September 2023, 13, 16, 75–76, https://www.iea.org/reports/net-zero-roadmap-a-global-pathway-to-keep-the-15-0c-goal-in-reach; IEA, *Net Zero by 2050: A Roadmap for the Global Energy Sector*, 2021, 18–21, 100–05; IPCC, *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. P.R. Shukla et al. (Cambridge, UK and New York, NY, USA: Cambridge University Press, 2022), Summary for Policymakers, para. B.6, Fig. SPM.5, https://www.ipcc.ch/report/ar6/wg3/.
25. Stockholm Environment Institute (SEI), Climate Analytics, E3G, IISD, and UNEP, *Phasing Down or Phasing Up? Top Fossil Fuel Producers Plan Even More Extraction Despite Climate Promises: Production Gap Report 2023*, November 2023, 21, https://doi.org/10.51414/sei2023.050.
26. Antonia Juhasz, "Exxon's Oil Drilling Gamble off Guyana Coast 'Poses Major Environmental Risk'," *Guardian*, August 17, 2021, https://www.theguardian.com/environment/2021/aug/17/exxon-oil-drilling-guyana-disaster-risk.
27. Oil Change International, "Troubled Waters: How North Sea Countries Are Fuelling Climate Disaster," March 2024, 6, https://priceofoil.org/content/uploads/2024/03/Troubled-Waters-Report.pdf.

28. Tess Geers et al., "Beyond Expectations: Ocean Solutions to Prevent Climate Catastrophe," OCEANA, November 2022, 4, https://oceana.org/wp-content/uploads/sites/18/2022/11/Oceana-Climate-and-Oceans-Report-FINALSINGLEPAGE.pdf.

29. Oslo Tingrett [OT] [Oslo District Court] 2024-01-18 Case No. 23-099330TVI-TOSL/05 (Nor.); Nerijus Adomaitis and Gwladys Fouche, "Three Norwegian Oil and Gas Field Permits Invalidated on Environmental Grounds," Reuters, January 18, 2024, https://www.reuters.com/business/energy/development-permits-3-norway-oil-gas-fields-are-invalid-court-rules-2024-01-18/. In October 2024, an appellate court reversed the interim injunction. The litigation is under appeal and remains pending.

30. R v Surrey County Council and others (2024), UKSC 20; Tom Clarke, "Future of New Oil and Gas Projects in UK Thrown into Doubt After Landmark Supreme Court Decision," Sky News, June 20, 2024, https://news.sky.com/story/future-of-new-oil-and-gas-projects-in-uk-thrown-into-doubt-after-landmark-supreme-court-decision-13155934.

31. Jenny Gross, "Oil Projects Must Consider Full Climate Impact, Top UK Court Rules," *New York Times*, June 21, 2024, https://www.nytimes.com/2024/06/21/world/europe/uk-supreme-court-oil-ruling.html.

32. For example: Friends of Earth v. Haaland, 583 F. Supp. 3d 113 (DC 2022); *Sustaining the Wild Coast NPC and Others v Minister of Mineral Resources and Energy and Others* 2022 (6) SA 589 at para. 121 (S. Afr.).

33. Mostafa Satiarvand et al., "Providing a Comprehensive Approach to Oil Well Blowout Risk Assessment." *PLoS ONE* 18, no. 12 (December 20, 2023): 2, https://doi.org/10.1371/journal.pone.0296086.

34. Keith Bradsher, "Relief Well Was Used to Halt Australian Spill," *New York Times*, May 2, 2010, https://www.nytimes.com/2010/05/03/us/03montara.html.

35. Suzanne Goldenberg, "Biologists Find 'Dead Zones' Around BP Oil Spill in Gulf," *Guardian*, June 30, 2010, https://www.theguardian.com/environment/2010/jun/30/biologists-find-oil-spill-deadzones.

36. Len Williams, "Tackling the Oceans' Dead Zones," Engineering and Technology, updated October 8, 2023, https://eandt.theiet.org/2022/05/18/tackling-oceans-dead-zones.

37. Panagiota-Myrsini Chronopoulou et al., "Origin and Fate of Methane in the Eastern Tropical North Pacific Oxygen Minimum Zone," *The Isme Journal* 11, no. 6 (February 28, 2017): 1395, https://doi.org/10.1038/ismej.2017.6; Lea Steinle et al., "Effects of Low Oxygen Concentrations on Aerobic Methane Oxidation in Seasonally Hypoxic Coastal Waters," *Biogeosciences* 14, no. 6 (March 29, 2017): 1631, https://doi.org/10.5194/bg-14-1631-2017; David Kirchman, "Dead Zones: Growing Areas of Aquatic Hypoxia are Threatening Our Oceans and Rivers," *OUP Blog* (blog), February 7, 2021, https://blog.oup.com/2021/02/dead-zones-growing-areas-of-aquatic-hypoxia-are-threatening-our-oceans-and-rivers/#:~:text=Hypoxic%20waters%20can%20release%20phosphorus,silent%20to%20the%20casual%20observer.

38. "FAQ: Ocean Deoxygenation," UC San Diego, last accessed June 5, 2024, https://scripps.ucsd.edu/research/climate-change-resources/faq-ocean-deoxygenation.

39. Alejandra Borunda, "We Still Don't Know the Full Impacts of the BP Oil Spill, 10 Years Later," *National Geographic*, April 20, 2020, https://www.nationalgeographic.com/science/article/bp-oil-spill-still-dont-know-effects-decade-later.

40. Irina Slav, "The Truth About The World's Deepest Oil Well," *Oil Price*, November 19, 2019, https://oilprice.com/Energy/Energy-General/The-Truth-About-The-Worlds-Deepest-Oil-Well.html.

41. Anna Crivellari et al., "Key Performance Indicators for Environmental Contamination Caused by Offshore Oil Spills," *Process Safety and Environmental Protection* 153 (September 2021): 60, https://doi.org/10.1016/j.psep.2021.06.048.

42. David A. Westerholm and Samuel Dean Rauch, III, *Deepwater Horizon Oil Spill: Final Programmatic Damage Assessment and Restoration Plan and Final Programmatic Environmental Impact Statement*, National Oceanic and Atmospheric Administration (NOAA), 2016, 4–57, 4–82, https://repository.library.noaa.gov/view/noaa/18084.

43. Russell Searancke, "Drillship Delight: First of Two Deep-water Giants Delivered to Transocean," *Upstream*, June 29, 2022, https://www.upstreamonline.com/rigs-and-vessels/drillship-delight-first-of-two-deep-water-giants-delivered-to-transocean/2-1-1247554; Slav, "The Truth About The World's Deepest Oil Well."

44. Peter Milne, "Oil Spills into Timor Sea from Troubled Montara Field off WA Coast," *Sydney Morning Herald*, June 21, 2022, https://www.smh.com.au/environment/conservation/oil-spills-into-timor-sea-from-troubled-montara-field-off-wa-coast-20220620-p5av4y.html.

45. Amy Mathews, "Environmental Justice Victory: Indonesian Seaweed Farmers Win, 12 Years After Montara Oil Spill," *Skytruth*, June 9, 2021, https://skytruth.org/2021/06/environmental-justice-victory-indonesian-seaweed-farmers-win-12-years-after-montara-oil-spill.

46. Hector Guzman, Stefanie Kaiser, and Ernesto Weil, "Assessing the Long-term Effects of a Catastrophic Oil Spill on Subtidal Coral Reef Communities off the Caribbean Coast of Panama (1985–2017)." *Marine Biodiversity* 50, 28 (April 6, 2020): 16, https://doi.org/10.1007/s12526-020-01057-9.

47. W. Judson Kenworthy et al., "Seagrass Response Following Exposure to Deepwater Horizon Oil in the Chandeleur Islands, Louisiana (USA)," *Marine Ecology Progress Series* 576 (August 3, 2017): 146, https://doi.org/10.3354/meps11983.

48. Jinxin Dong et al., "Climate Change Impacts on Coastal and Offshore Petroleum Infrastructure and the Associated Oil Spill Risk: A Review," *Journal of Marine Science Engineering* 10, no. 7 (June 22, 2022): 6–7, https://doi.org/10.3390/jmse10070849.

49. Petrissa Eckle, Peter Burgherr, and Edouard Michaux, "Risk of Large Oil Spills: A Statistical Analysis in the Aftermath of Deepwater Horizon." *Environmental Science and Technology* 46, no. 23 (November 5, 2012): 13007, https://doi.org/10.1021/es3029523.

50. "How Does Oil Impact Marine Life?," National Ocean Service, NOAA, last accessed June 5, 2024, https://oceanservice.noaa.gov/facts/oilimpacts.html?source=post_page-----------------------------#:~:text=Oil%20destroys%20the%20insulating%20ability,become%20trapped%20in%20 oil; "How Do Oil Spills Affect Sea Turtles?," Office of Response and Restoration, NOAA, published June 16, 2016, https://blog.response.restoration.noaa.gov/how-do-oil-spills-affect-sea-turtles#:~:text=When%20sea%20turtles%20surface%20in,mired%20and%20unable%20to%20swim; "2010–2014 Cetacean Unusual Mortality Event in Northern Gulf of Mexico (Closed)," Office of Protected Resources, NOAA, September 12, 2019, https://www.fisheries.noaa.gov/national/marine-life-distress/2010-2014-cetacean-unusual-mortality-event-northern-gulf-mexico.

51. Gianna Melillo, "Humans Responsible for More Oil slicks Than Previously Thought," Hill, June 16, 2022, https://thehill.com/changing-america/sustainability/climate-change/3522389-humans-responsible-for-more-oil-slicks-than-previously-thought/; Kim, Tae-Ho et al., "Analysis of the Contribution of Wind Drift Factor to Oil Slick Movement Under Strong Tidal Condition: Hebei Spirit Oil Spill Case." *PLoS One* 9, no. 1 (2014): 1, https://doi.org/10.1371/journal.pone.0087393.

52. "Oils (Hydrocarbons)," UNEP, accessed June 5, 2024, https://www.unep.org/cep/oils-hydrocarbons.

53. Xinya Chen et al., "Effects of Oil Characteristics on the Performance of Shoreline Response Operations: A Review," *Frontiers in Environmental Science* 10 (October 20, 2022): 1–2, https://doi.org/10.3389/fenvs.2022.1033909.

54. Zunaira Asif et al., "Environmental Impacts and Challenges Associated with Oil Spills on Shorelines," *Journal of Marine Science and Engineering* 10, no. 6 (May 31, 2022): 3, https://doi.org/10.3390/jmse10060762. .

55. Asif et al., "Environmental Impacts and Challenges Associated with Oil Spills on Shorelines," 3.

56. Andrew Nikiforuk and Hakai Magazine, "Why We Pretend to Clean Up Oil Spills," *Smithsonian Magazine*, July 12, 2016, https://www.smithsonianmag.com/science-nature/oil-spill-cleanup-illusion-180959783/.

57. Nikiforuk and Hakai Magazine, "Why We Pretend to Clean Up Oil Spills."

58. Nikiforuk and Hakai Magazine, "Why We Pretend to Clean Up Oil Spills"; Julie Dermansky, "Three Years After the BP Spill, Tar Balls and Oil Sheen Blight Gulf Coast," *Atlantic*, April 20, 2013, https://www.theatlantic.com/national/archive/2013/04/three-years-after-the-bp-spill-tar-balls-and-oil-sheen-blight-gulf-coast/275139/.

59. Roberto Rico-Martínez et al., "Synergistic Toxicity of Macondo Crude Oil and Dispersant Corexit 9500A® to the *Brachionus plicatilis* Species Complex (Rotifera)," *Environental Pollution* 173 (February 2013) 8, http://dx.doi.org/10.1016/j.envpol.2012.09.024; Alameda, Rodrigo, Cammie Hyatt, and Edward J. Buskey. "Toxicity of Dispersant Corexit 9500A and Crude Oil to Marine Microzooplankton," *Ecotoxicology and Environmental Safety* 106 (August 2014), https://doi.org/10.1016/j.ecoenv.2014.04.028.

60. Bakke, Klungsøyr, and Sanni, "Environmental Impacts of Produced Water and Drilling Waste Discharges from the Norwegian Offshore Petroleum Industry," 154.

61. Stanislav Patin, "Offshore Oil and Gas Production and Transportation," in *Handbook on Marine Environment Protection*, eds. M Salomon, T Markus (Fall 2017): 155.

62. Tracy K. Collier et al., "Effects on Fish of Polycyclic Aromatic Hydrocarbons (PAHS) and Naphthenic Acid Exposures," in *Fish Physiology*, 2013, 195–255, https://doi.org/10.1016/b978-0-12-398254-4.00004-2.

63. Sonnich Meier et al., "Effects of Alkylphenols on the Reproductive System of Atlantic Cod (*Gadus morhua*)." *Aquatic Toxicology* 81, no. 2 (February 28, 2007): 208, https://doi.org/10.1016/j.aquatox.2006.12.002.

64. Cordes et al., "Environmental Impacts of Deep-Water Oil and Gas Industry: A review to Guide Management Strategies," 1–2, 10, https://doi.org/10.3389/fenvs.2016.00058.

65. Patin, "Offshore Oil and Gas Production and Transportation," 155.

66. Laura F. Marangoni et al., "Impacts of Artificial Light at Night in Marine Ecosystems — A Review," *Global Change Biology* 28, no. 18 (May 18, 2022): 5347, 5349, 5351, https://doi.org/10.1111/gcb.16264; Rasna Rajkhowa, "Light Pollution and Impact of Light Pollution," *International Journal of Science and Research* 3, no. 10 (September 2014): 684, https://www.ijsr.net/archive/v3i10/T0NUMTQyMTA=.pdf.

67. Robert A. Ronconi, Karel A. Allard, and Philip D. Taylor, "Bird Interactions with Offshore Oil and Gas Platforms: Review of Impacts and Monitoring Techniques," *Journal of Environmental Management* 147 (January 2015): 35, https://doi.org/10.1016/j.jenvman.2014.07.031.

68. Rajkhowa, "Light Pollution and Impact of Light Pollution," 864.

69. Ronconi, Allard, and Taylor, "Bird Interactions with Offshore Oil and Gas Platforms," 35.

70. Christine Erbe and Craig McPherson, "Underwater Noise from Geotechnical Drilling and Standard Penetration Testing," *The Journal of the Acoustical Society of America* 142, no. 3 (September 19, 2017): EL284, https://doi.org/10.1121/1.5003328.

71. Marta Solé and Michel André, "Editorial: Marine Invertebrates and Sound., *Frontiers in Marine Science* 10 (July 26, , 2023): 1–2, https://doi.org/10.3389/fmars.2023.1257952; Koen C. Bröker, "An Overview of Potential Impacts of Hydrocarbon Exploration and Production on Marine Mammals and Associated Monitoring and Mitigation Measures," *Aquatic Mammals* 45, no. 6 (2019): 577, https://doi.org/10.1578/AM.45.6.2019.576; Zanagee Artis, "Marine Life: The Casualties of Offshore Drilling," NRDC (blog) August. 17, 2023, https://www.nrdc.org/bio/zanagee-artis/marine-life-casualties-offshore-drilling#:~:text=Increased%20vessel%20traffic%20during%20exploration,cause%20serious%20injury%20or%20death.

72. Ben Doherty, "'Very Hard Life Now': 12 years After the Montara Oil Spill, Indonesians Are Still Fighting to Be Heard," *Guardian*, January 15, 2022, https://www.theguardian.com/environment/2022/jan/16/very-hard-life-now-12-years-after-the-montara-oil-spill-indonesians-are-still-fighting-to-be-heard.

73. *Daniel Aristabulus Sanda v Pttep Australasia (Ashmore Cartier) Pty Ltd* [2016] NSWLR 1245 (Austral.).

74. Tammy Mills, "Class Action Win for Indonesian Farmers After 2009 Montara Oil Spill," *Sydney Morning Herald*, March 21, 2021, https://www.smh.com.au/national/class-action-win-for-indonesian-farmers-after-2009-montara-oil-spill-20210321-p57cmz.html.

75. Doherty, "'Very Hard Life Now.'"

76. "PTTEP Agrees $127m Montara Oil Spill Settlement," *Energy Voice*, November 22, 2022, https://www.energyvoice.com/oilandgas/462388/pttep-agrees-127m-montara-oil-spill-settlement/.

77. Dejan Brkić and Pavel Praks, "Probability Analysis and Prevention of Offshore Oil and Gas Accidents: Fire as a Cause and a Consequence," *Fire* 4, no. 4 (October 14, 2021): 1, https://doi.org/10.3390/fire4040071.

78. Zhigang Lan, "Blowout Accident Impact Analysis Method for the Siting of Offshore Floating Nuclear Power Plant in Offshore Oil Fields," *Science and Technology of Nuclear Installations* (October 21, 2019): 4, 7, https://doi.org/10.1155/2019/3491201.

79. Institution of Chemical Engineers (IChemE), Fiona Macleod and Stephen Richardson, "Piper Alpha — What Have We Learned?," *Loss Prevention Bulletin* 261 (June 2018): 3, https://www.icheme.org/media/1982/lpb261_pg03.pdf.

80. IchemE, 3.

81. NOAA, "Deepwater Horizon Oil Spill Settlements: Where the Money Went," last updated April 20, 2017, https://www.noaa.gov/explainers/deepwater-horizon-oil-spill-settlements-where-money-went#:~:text=On%20April%2020%2C%202010%2C%20the,11%20people%20and%20 injuring%2017.

82. IChemE, "Piper Alpha — What Have We Learned?," 9.

83. Ann M. Middlebrook et al., "Air Quality Implications of the Deepwater Horizon Oil Spill," *Proceedings of the National Academy of Sciences* 109, no. 50 (December 28, 2011): 20281, https://doi.org/10.1073/pnas.1110052108.

84. NOAA, "Air Pollution Levels from Deepwater Horizon Spill Similar to Large Urban Area," December 20, 2011, https://research.noaa.gov/2011/12/20/air-pollution-levels-from-deepwater-horizon-spill-similar-to-large-urban-area/.

85. Udeme Sunday Udofia et al., "Investigating the Origin and Tissue Concentration of Polycyclic Aromatic Hydrocarbons in Seafood and Health Risk in Niger Delta, Nigeria." *Environmental Science Processes and Impacts* 23, no. 11 (October 18, 2021): 1804, https://doi.org/10.1039/d1em00249j; Masato Honda and Nobou Suzuki, "Toxicities of Polycyclic Aromatic Hydrocarbons for Aquatic Animals," *International Journal of Environmental Research and Public Health* 17, no. 4 (February 20, 2020): 4–5, https://doi.org/10.3390/ijerph17041363.

86. Natural Resources Defense Council (NRDC), "Summary of Information concerning the Ecological and Economic Impacts of the BP Deepwater Horizon Oil Spill Disaster," June 2015, 2, https://www.nrdc.org/sites/default/files/gulfspill-impacts-summary-IP.pdf.

87. Statista, "Total Contribution of Travel and Tourism to the Gross Domestic Product in the Caribbean in 2022, by Country or Territory," May 22, 2024, https://www.statista.com/statistics/814155/caribbean-total-contribution-travel-tourism-gdp-country/; Marc D. Spalding, et al., "Estimating Reef-Adjacent Tourism Value in the Caribbean," The Nature Conservancy, October 31, 2018, 4, https://www.nature.org/content/dam/tnc/nature/en/documents/Reef_Adjacent_Tourism_Value_Caribbean_Study.pdf (explaining that, at the time the report was published, tourism accounted for 15 percent of GDP and over 13 percent of jobs in the region).

88. "Innovative Fisheries Insurance Benefits Caribbean Fisherfolk," The World Bank, September 20, 2019, https://www.worldbank.org/en/news/feature/2019/09/20/innovative-fisheries-insurance-benefits-caribbean-fisherfolk

89. "Fears of an Oil-Spill Off the Coast of Trinidad and Tobago," BBC, October 21, 2020, https://www.bbc.co.uk/newsround/54615253.

90. Danielle Buttke et al., "Mental Health Needs Assessment After the Gulf Coast Oil Spill — Alabama and Mississippi, 2010," *Prehospital and Disaster Medicine* 27, no. 5 (August 21, 2012), 407, https://doi.org/10.1017/S1049023X12001100.

91. Owen Pinnel, Sarah Ibrahim, and Esme Stallard, "Toxic Gas Putting Millions at risk in Middle East, BBC Finds," *BBC*, November 28, 2023, https://www.bbc.com/news/science-environment-67522413.

92. Rice University, "Gas Flares Tied to Premature Deaths: Effect of Black Carbon Particles on Health," *Science Daily*, February 28, 2022, https://www.sciencedaily.com/releases/2022/02/220228103818.htm.

93. Urenmisan Afinotan, "How Serious Is Nigeria about Climate Change Mitigation through Gas Flaring Regulation in the Niger Delta?" *Environmental Law Review* 24, no. 4 (November 30, 2022): 293, https://doi.org/10.1177/14614529221137142.

94. Chen Chen et al., "Black Carbon Emissions and Associated Health Impacts of Gas Flaring in the United States," *Atmosphere* 13, no. 3 (February 25, 2022): 11, https://doi.org/10.3390/atmos13030385.

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