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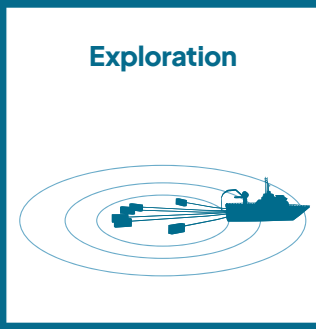
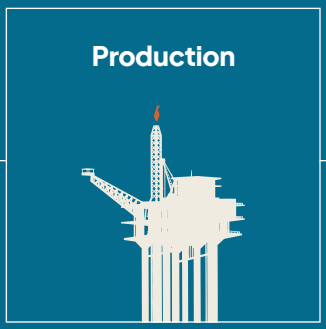
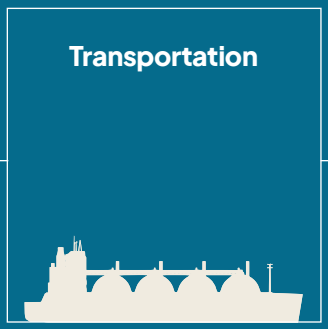
ENVIRONMENTAL LAW

Offshore, Off-Limits

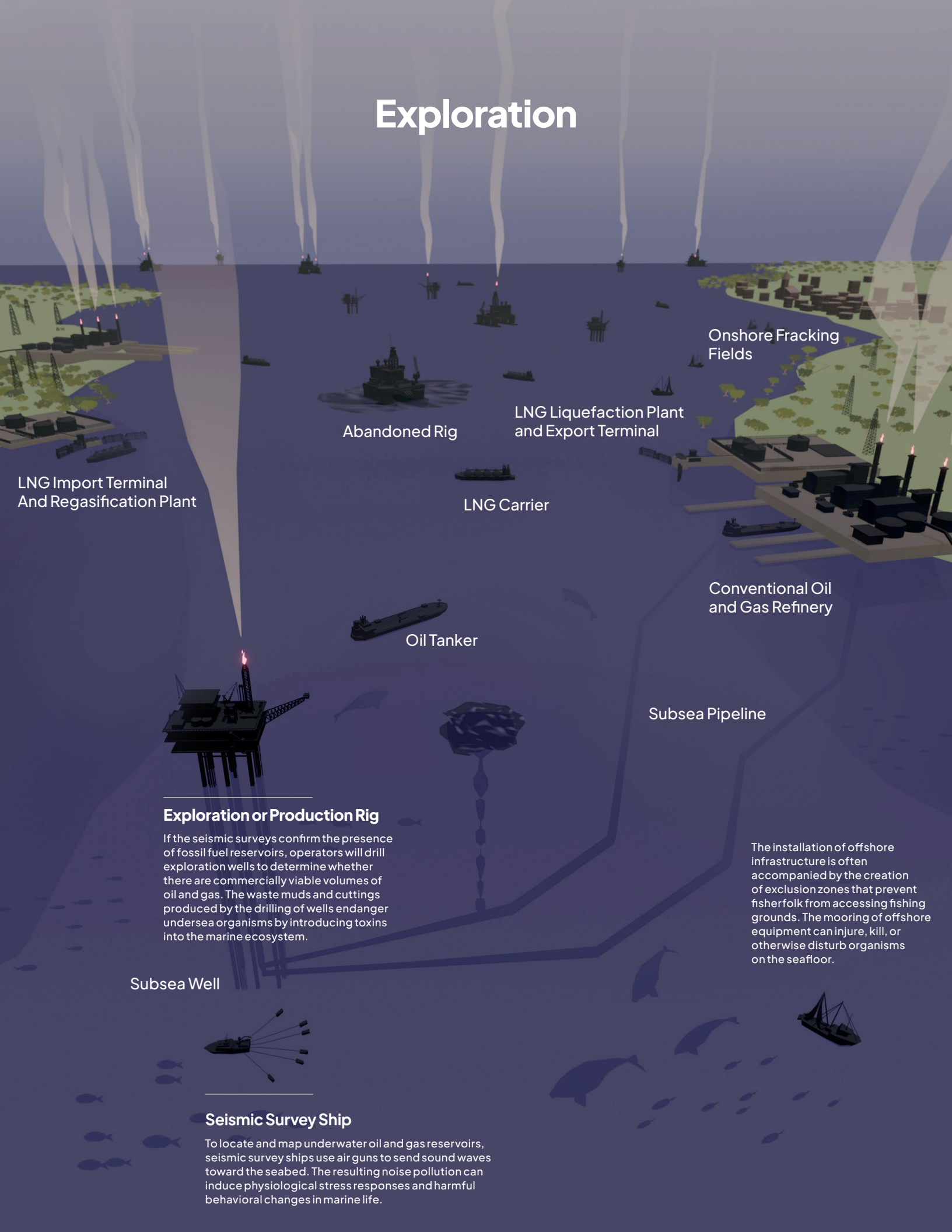
The Risks of Offshore Oil & Gas Exploration







Exploration



Exploration or Production Rig

If the seismic surveys confirm the presence of fossil fuel reservoirs, operators will drill exploration wells to determine whether there are commercially viable volumes of oil and gas. The waste muds and cuttings produced by the drilling of wells endanger undersea organisms by introducing toxins into the marine ecosystem.

The installation of offshore infrastructure is often accompanied by the creation of exclusion zones that prevent fisherfolk from accessing fishing grounds. The mooring of offshore equipment can injure, kill, or otherwise disturb organisms on the seafloor.

Seismic Survey Ship

To locate and map underwater oil and gas reservoirs, seismic survey ships use air guns to send sound waves toward the seabed. The resulting noise pollution can induce physiological stress responses and harmful behavioral changes in marine life.

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 the exploration of undersea oil and gas deposits.

Key Takeaways

- Exploration is the first step toward extracting more oil and gas, the production and use of which release planet-warming emissions that are driving the climate crisis.
- Noise pollution generated by subsea exploration activities can seriously harm marine life, from microorganisms to whales, by inducing physiological stress responses and behavioral changes that jeopardize organisms' survival.
- Exploration activities, from installing rigs and equipment to drilling test wells, can introduce heavy metals and other toxins into the marine ecosystem.
- These impacts threaten the health, productivity, and resilience of marine ecosystems, which are crucial for biodiversity and the well-being and livelihoods of coastal and fisherfolk communities around the world.

Campo Basin Offshore Oil Field

What Is Offshore Exploration?

Exploration is the first phase of offshore oil and gas production. Its purpose is to locate subsea oil and gas that can be commercially extracted. This phase generally begins with marine seismic surveys to identify and estimate the volume of oil and gas contained in geological formations under the ocean floor.[1] If a prospective reserve is located, operators will drill exploration wells to confirm whether there are commercial quantities of oil or gas under the seabed, a process that can take several months. Such exploration activities occur at varying depths. Although exact definitions may differ across jurisdictions, shallow water development typically occurs at depths below 1,000 feet (ft) (~300 meters (m)), deepwater development at around 1,000–2,500 ft (~300–800 m), and ultra-deepwater development at over 2,500 ft.[2]

Different ocean depths require different equipment and installations, but whether in shallow, deep, or ultra-deep waters, exploration activities can cause lasting harm to oceans. Seismic surveys, in which repeated sound waves are sent underwater, can significantly harm marine life. Exploratory drilling poses additional risks related to the installation, transportation, operation, and removal of heavy equipment, as well as the management of chemical inputs and toxic waste streams. More fundamentally, exploration is the first step toward unlocking potentially massive quantities of greenhouse gas emissions, which drive climate change and its devastating consequences for people and the environment around the globe.

How Is Offshore Exploration Carried Out?

Finding hydrocarbon reserves, determining their quantity and depth, and preparing for extraction is a technically complex process that combines geological mapping and drilling. Exploration typically comprises the following stages:

Geophysical Surveys

Marine seismic surveys map the subsurface geology of a prospective site.[3] The technologies used in such surveys can have significant adverse impacts on marine populations, as discussed below. Surveys are conducted from vessels that use an array of underwater air guns to send pulses of high-energy, low-frequency sound waves toward the seabed.[4] These are recorded by sensitive underwater microphones called hydrophones, which are towed behind a survey vessel on buoyant streamers.

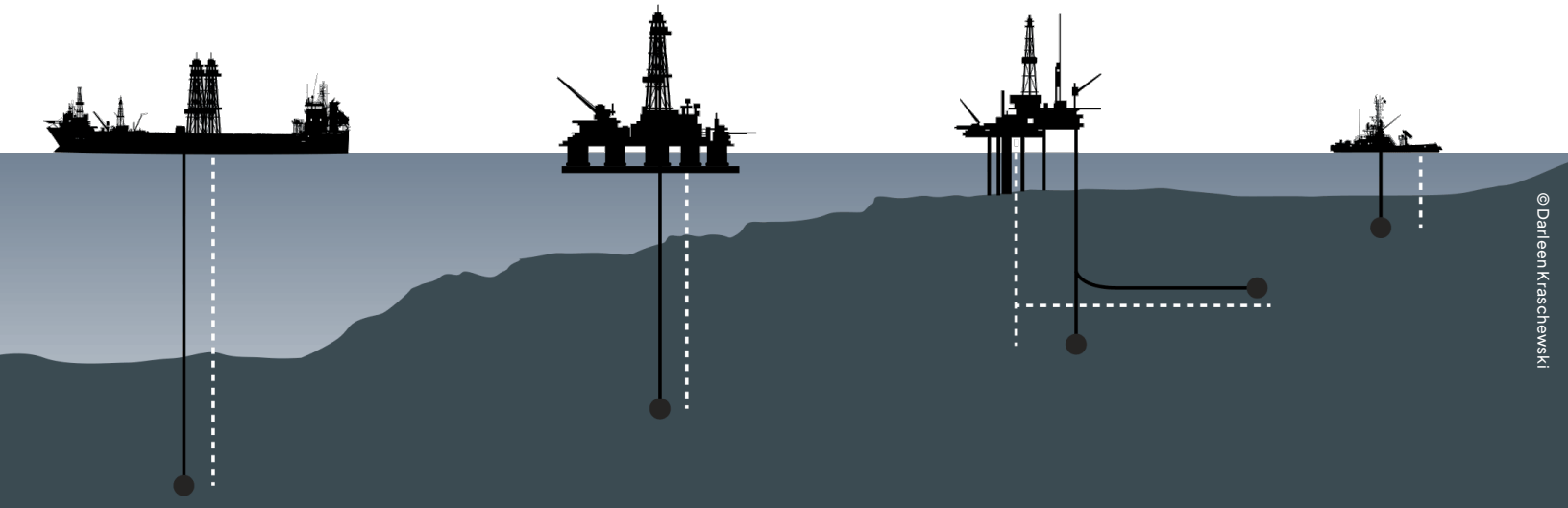
Air gun blasts can reach deafening sound levels of 260 decibels (dB), noise louder than a rocket launch (which is 160 dB for those nearby),[5] and can travel underwater up to 2,500 miles.[6] They are also relentless, firing approximately every 10 seconds for months at a time.[7] Although all seismic surveys create underwater noise pollution, 3D and 4D surveys involve more intense seismic disturbances to the marine environment than the 2D variety since they deploy multiple sound sources and are more repetitive.[8]

Exploratory Drilling

Drilling into the seabed to take samples of the underlying rock or "core" requires the erection of massive structures and the deployment of energy-intensive processes. This is an extremely risky undertaking as various types of mobile offshore drilling units (MODUs) are susceptible to accidents. Among the different types of MODUs, jack-up rigs are more common in shallower waters, whereas semi-submersible rigs and drill ships are typically used farther out at sea at greater depths.[9]

After erecting the drilling units, operators typically drill a well, in a process called spudding. Pipes are driven into the seabed before water is pumped at high pressure to remove rock and sediment. A blowout preventer (BOP) is then installed, which allows the well to be closed off in an emergency.[10] However, extremely dangerous high-pressure blowouts can occur unexpectedly, especially before the BOP has been installed.[11]

In exploratory drilling using chemical-laden drilling muds suspended in either water or oil, introduces additional risks. Those muds serve to lubricate and cool the drill, act as a medium to remove drill cuttings from the bottom of the well, and act as a sealant to prevent blowouts.[12] Drilling muds contain toxic additives such as diesel fuel and heavy metals that, when introduced into the surrounding waters, can smother and have a toxic effect on marine organisms.[13]



DRILL SHIP
Operates at water depth of: 500 – 650m.
DRILLING DEPTH: 12,000+m

SEMI-SUBMERSIBLE
Operates at water depth of: 500 – 3,000m.
DRILLING DEPTH: 10,000+m

JACK-UP RIG
Operates at water depth of: 25 – 150m.
DRILLING DEPTH: 9,000+m.
HORIZONTAL DRILLING MAXIMUM: 4,000+m

BARGE
Operates at water depth of: 5 – 50m.
DRILLING DEPTH: 6,000+m

Appraisal Drilling

More wells may be drilled to substantiate initial findings and map the physical dimensions of the exploration area in greater detail.[14] Some of those appraisal wells may be used for production, while others will be abandoned. Because oil and gas companies often poorly manage the abandonment process (see the Decommissioning brief in this series), well leaks are common and extremely damaging. They expose marine life to toxic substances and release planet-warming gases like methane.

What Are the Risks Posed by Offshore Exploration?

Environmental and Biodiversity Risks

Routine oil and gas exploration activities can leave extensive environmental damage in their wake. The noise associated with seismic testing and drilling activities is a principal cause of harm to surrounding marine life. Direct physical disturbance of the marine ecosystem, from the discharge of drill cuttings and fluids, along with the construction and installation of drilling units, exacerbates these vulnerabilities.

Noise Pollution

During exploration, noise from air gun blasts, ship sonar, and general vessel traffic can have significant adverse impacts on marine life in at least two ways: (1) by inducing a physiological stress response and (2) by disrupting biologically-essential behavior such as mating or foraging.

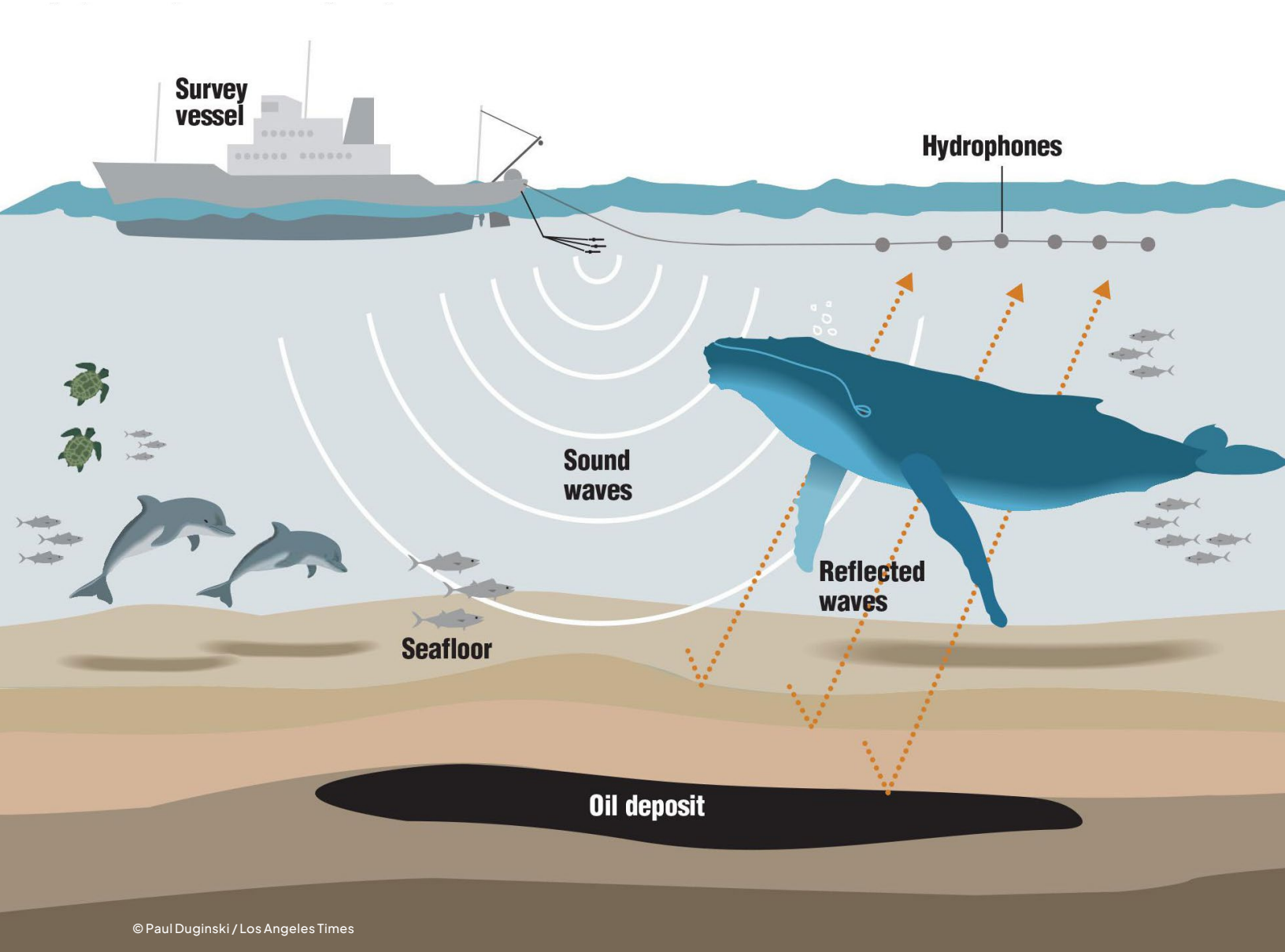
Seismic surveys can induce profound physiological stress in a wide array of ocean life, from shellfish to marine mammals. Loud noises can severely damage animals' sensory receptors, such as the statocyst, an organ responsible for orientation, balance, and predator response found in aquatic invertebrates such as lobsters and mollusks.[15] Noise pollution from seismic blasts can also damage neuromasts, a sensory organ in fish that likewise plays an important role in escape reactions.[16] At close range, air gun blasting can also induce chronic stress, permanent hearing loss, internal bleeding, and blindness, especially in fish with swim bladders.[17] Furthermore, studies of the effects of seismic air guns on the eggs and larvae of fish have observed decreased egg viability, increased embryonic mortality, or decreased larval growth with exposure to sound levels of 120 underwater decibels (dB re 1 µPa-m)[18] — far below typical noise levels from full-scale seismic survey activities, which reach 248–255 dB re 1 µPa-m.[19]

Marine seismic surveys also threaten the health and productivity of aquatic microorganisms, and thus have the potential to destabilize global marine ecosystems. Experimental air gun signal exposure has been shown to cause a two- to three-fold increase in the mortality of adult and larval zooplankton at a range of 1.2 km.[20] Because zooplankton are key components of the aquatic food chain — providing the main pathway for energy for small primary producers to large consumers like marine mammals, turtles, and fish[21] — a population decline could have resounding ecological impacts.

Noise from other machine and transport equipment involved in offshore exploration compounds the disruptive impacts of unrelenting seismic testing. The incessant noise of container ships, naval sonar, and shallow water jack-up rigs (which operate loud diesel engines, mud pumps, ventilation fans, and electrical generators) can affect animal health and behavior patterns, discussed further below. Cavitation, the sound from the synchronous collapse of bubbles created by a ship's propeller and the rumble of ship engines, is one of the main causes of background sound in the ocean.[22] Additionally, the construction of shallow-water platforms can also be a source of harmful noise.[23] This adds to the noise produced by general aircraft and vessel activity associated with rig construction, which increases the risk of ships colliding with marine mammals that may be forced to abandon their habitats.

The thundering sound of seismic surveys and other sources of noise pollution can also trigger harmful behavioral responses in marine life, especially for those animals that rely on their hearing to hunt, communicate, and navigate.[24] High stress levels induced by air gun blasting are known to change mating behavior and alter whales' dive and respiratory patterns.[25] This can, in turn, trigger decompression sickness and increase the likelihood of beach strandings.[26] Habitat displacement and slower migration speeds have also been recorded in response to seismic surveys.[27] For example, in 2019, a study found an 88 percent decrease in sightings of baleen whales and a 53 percent decrease in sightings of toothed whales during active oil and gas seismic surveys compared to control surveys.[28]

For some species of whale, dolphin, and porpoise — which hunt prey and communicate through echolocation — elevated noise levels in the ocean also spell disaster for their ability to find food. One study found that whale prey capture attempts may be 19 percent lower during air gun noise exposure.[29] A single seismic survey can cause endangered fin and humpback whales to stop vocalizing — a behavior essential to foraging — over an area at least 100,000 square nautical miles in size.[30] What's worse, 80 percent of communications of fin, humpback, and minke whales are "masked" by anthropogenic noise.[31] Similarly, seals have displayed dramatic avoidance behavior and disrupted feeding systems when exposed to air gun blasts.[32]



Legal Challenges to Offshore Exploration

The severe impacts of seismic testing on marine ecosystems, fisheries, and the communities whose livelihoods and cultures depend on them have led some courts to halt oil and gas exploration activity. In South Africa, for example, deepwater oil exploration using seismic testing has faced enormous backlash from local communities and environmental activists, prompting legal challenges.

The South African government first granted Shell and Impact Africa oil and gas exploration rights to the relatively untouched and ecologically sensitive Wild Coast in 2014, renewing these rights in 2021.[33] In November 2021, four environmental and human rights organizations filed an interdict application against Shell, Impact Africa, South Africa's Minister of Mineral Resources and Energy, and its Minister of Forestry, Fisheries and the Environment to stop the companies from conducting seismic surveys. The applicants alleged that Shell had failed to meaningfully consult the Indigenous and coastal communities whose livelihoods would be affected by the seismic blasting activities and presented evidence of the risk of irreparable harm to local fisheries and marine life, including vulnerable and threatened species of fish and cetaceans. The lawsuit invoked the precautionary principle — which is enshrined in South Africa's National Environmental Management Act[34] — arguing that "the precautionary approach on species of such dire conservation concern is imperative if we are to conserve them into the future."[35]

In 2022, the High Court of South Africa agreed with the applicants and ordered an immediate halt to Shell's seismic surveys. The court found that the government had failed to consider affected communities' spiritual and cultural rights and their rights to livelihood and that there had not been meaningful consultations, which "consist not in the mere ticking of a checklist."[36] The court also found that "the onus rests on [the respondents]" to show why the precautionary principle did not apply when there was disagreement on whether the adverse impacts of the seismic surveys had been adequately mitigated.[37] The government and companies appealed the decision, and in June 2024, the appellate court upheld the ruling but effectively reinstated exploration rights pending new consultations that "cure" the earlier deficiencies. As of the time of writing (January 2025), the situation remains ongoing.

Arguments related to the lack of consultation with affected communities, inadequate assessment and disclosure of risks, and the impacts on marine fauna have also been deployed and upheld by courts in other domestic legal challenges against offshore exploration, including in Argentina[38] and Australia.[39]

Physical Disturbances and Contamination

Massive offshore exploration rigs are susceptible to collapse, which risks permanent environmental damage and fatal consequences for rig workers. Shallow water jack-up rigs and deepwater semi-submersible rigs rely on ballast control systems, a network of pipes, valves, pumps, and tanks, to control the rig's buoyancy.[40] For semi-submersibles, pontoon-like structures are used as buoyancy tanks allowing the rig to float,[41] but malfunctions to the system can cause flooding that sinks the rig.[42] System failures can also lead to high-pressure explosions like the one on the Petrobras 36 Oil Platform in 2001, which killed eleven crew members and spilled 1,200 m^3 of diesel oil and 300 m^3 of oil into the Atlantic Ocean's Campos Basin.[43]

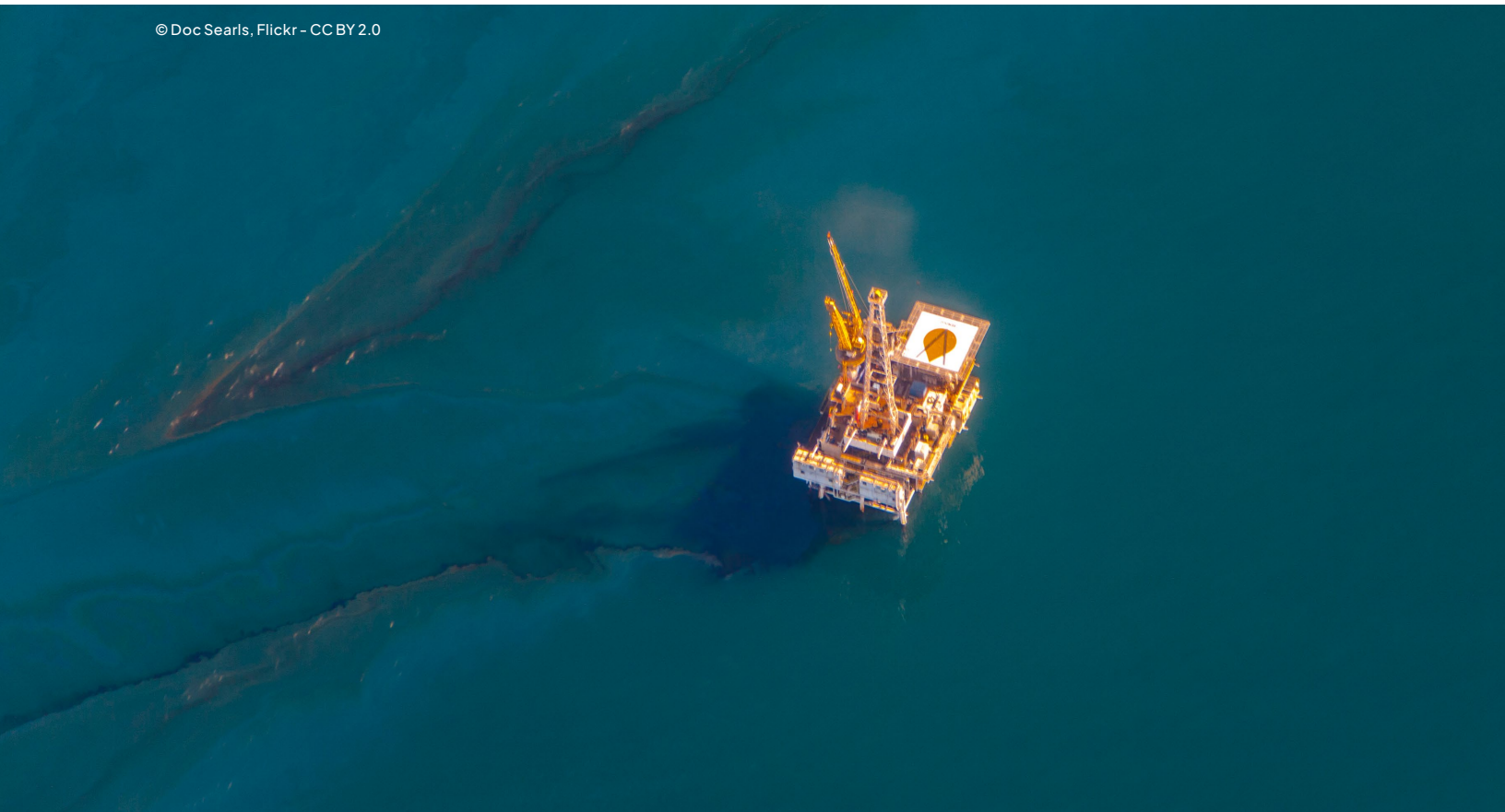
Jack-up rigs — floating barges with movable legs attached to the hull — are among the most common types of offshore platforms. To erect jack-up rigs, seawater is injected into the hull so the legs can properly grip the seabed.[44] The water is then discharged to lift the legs away from the surface, raising the drilling platform above the water line.[45] However, adding weight to the rig's base risks "punching through" the seabed,[46] causing its collapse, as happened in 2021 with ConocoPhillips' Naga-7 rig, which sank offshore Malaysia.[47]

Exploration activity, from the mooring of offshore equipment to the drilling of wells, can injure, kill, or otherwise disrupt marine organisms. In shallow waters, the legs of jack-up rigs and other movable structures extending to the bottom of the seafloor can cause ecosystem disturbances, including by affecting sedimentation patterns and facilitating the introduction of non-native and invasive species.[48] Such impacts can disrupt and degrade marine habitats in and near shallow waters — including coral reefs, mangroves, and seagrass meadows — which serve as nurseries and critical habitats for coastal and marine species, fishing grounds for local communities, and buffers against waves and storm surges. In deepwater settings, where semi-submersible rigs or drillships are moored, anchors dragged along the seabed harm benthic organisms (those that live at the bottom of the sea) like deep-sea coral and sponges.[49] Deep-sea organisms generally grow slower, live longer, and are less abundant than their shallow-water counterparts.[50] Thus, in most deep-sea ecosystems, benthic communities cannot recolonize quickly after disturbances[51] — with the process taking up up to 10 years in deeper colder water ecosystems[52] — making them very sensitive to oil and gas exploration.

The waste muds and cuttings produced by drilling exploration wells endanger benthic organisms further by introducing other toxic materials into the marine ecosystem.[53] Oil-based drilling muds contain clays, colloidal asphalts (insoluble molecular substances found in crude oil), emulsifiers, polymers, and other toxic additives, including weighting agents like calcium carbonate and barium sulfate.[54] Extensive discharges of oil-based cuttings result in large, toxic waste deposits beneath and around the platforms, hindering the rehabilitation of hard corals.[55]

Water-based drilling muds also pose numerous environmental hazards. While their main components may be heavily diluted, like other muds, water-based muds commonly contain chemical additives called polycyclic aromatic hydrocarbons (PAHs) and metals such as arsenic, barium, chromium, cadmium, copper, iron, lead, mercury, nickel, and zinc. The suspension of fine particles of PAHs, which are toxic and carcinogenic, can induce cardiac defects in fish and cause DNA damage, embryotoxicity, and developmental issues in other aquatic organisms.[56] Heavy metals pose a serious threat to marine ecosystems and the human communities that depend on them because, even in low concentrations,[57] they are highly toxic, long-lasting, and non-biodegradable.[58] Their biotoxicity also increases at lower pH levels,[59] which means that ocean acidification only amplifies their detrimental effects on the marine environment.[60] At the same time, in a dangerous feedback loop, marine pollutants like heavy metals and oil can cause the photosynthesis rates of microorganisms to drop while increasing their respiration rates, thereby boosting carbon dioxide (CO_2) levels and causing oceans to become even more acidic.[61]

Water-based muds also drive microplastic pollution. Chemicals used during exploratory drilling, including demulsifiers and corrosion inhibitors, contain microplastics, which are discharged into the marine environment.[62] Such discharges contribute to higher-than-average rates of microplastics detected in sediments and animals near oil and gas structures and exacerbate the global plastics pollution crisis.[63] It has been estimated that there are over 170 trillion plastic particles floating in the ocean, weighing between 1.1 and 4.9 million tons.[64]



Improper use of drilling muds can also lead to high-pressure well blowouts. Using the wrong density of mud can create problems with pressure related to the accumulation and movement of gas in the well, posing a potential risk of explosion at the surface.[65]

Indeed, the risk of blowouts is not unique to the production phase but can also occur during exploratory drilling. The 2010 Deepwater Horizon disaster in the Gulf of Mexico — the largest oil spill in the history of marine oil drilling operations — was caused by a blowout during exploratory drilling. Drilling during the exploration phase can have heightened risks because it occurs in areas where the geologic and underwater conditions are relatively uncertain.[66] However, because the ecological and human rights impacts of blowouts and accompanying oil spills are similar, whether during the exploration or production phases, these impacts and lessons drawn from Deepwater Horizon are discussed fully in the Production brief.

Climate Risks

The direct environmental impacts of offshore oil and gas exploration are compounded by its adverse impact on the global climate. Not only do zooplankton, threatened by offshore exploration, play a pivotal role in the ocean food chain[67] — they also play a critical role in climate regulation by photosynthetically fixing and storing massive amounts of carbon.[68] Oil and gas exploration activities interfere with that role through seismic air gun blasting and the artificial light at offshore oil and gas platforms, which disrupt the behavior and migration of zooplankton.[69]

By endangering whale populations, exploration activities also imperil the ocean's function as a carbon sink. Whales have a multiplier effect of increasing phytoplankton production. Phytoplankton contribute at least 50 percent of all oxygen to the atmosphere by capturing around 37 billion metric tons of CO_2, an estimated 40 percent of all CO_2 produced[70] — roughly equivalent to the amount of CO_2 captured from four Amazon forests' worth of trees.[71]

Running a rig's drilling equipment is inherently energy-intensive. While few published studies specifically assess the climate footprint of the oil and gas exploration phase in isolation, heavy reliance on exploration machinery on fossil power means considerable emissions. Offshore drilling units used for both exploratory and production wells are powered in part by diesel generators that use around 20–45 m^3 of fuel a day and emit potent greenhouse gases (GHG) like CO_2 and nitrogen oxides (NO_x),[72] in addition to carbon monoxide (CO),[73] which is highly poisonous and flammable.

More fundamentally, exploration is the first step toward extracting more oil and gas, which releases planet-warming emissions when used as intended. Fossil fuels are the overwhelming source of GHG emissions driving anthropogenic climate change and its catastrophic impacts on people and ecosystems. Oil, gas, and coal account for more than 75 percent of GHG emissions and nearly 90 percent of all CO_2 emissions.[74] Fossil fuel production — whether onshore or offshore — inevitably leads to emissions across its phases, from the extraction and processing of oil, gas, and coal to their transport and intended end use, primarily combustion. Thus, halting new exploration is the most effective way to avoid new fossil fuel pollution and the devastating consequences it engenders. Indeed, one study estimated that, in the US, ending the issuance of new exploration licenses for offshore oil and gas could prevent over 19 billion metric tons of GHG emissions — the equivalent of making roads in the country car-free for 15 years.[75]

Health, Livelihood, and Cultural Risks

Offshore oil and gas exploration threatens the health and productivity of marine ecosystems crucial for biodiversity, food security, and economic well-being. Worldwide, oceans provide around 182 million metric tons of seafood and 36 million metric tons of algae to the world's food supply every year.[76] Seismic air gun blasting decreases catch rates of commercial fish species by about 50 percent on average over thousands of square miles, with bigger losses closer to the source.[77] Exploration activities thus pose a threat to the livelihoods of nearly 30 million coastal Indigenous Peoples who depend on fishing worldwide and the 260 million who are employed by small-scale fisheries.[78] For instance, reportedly, when Shell began seismic surveys off the coast of Namibia in 2012, a sudden drop in catches led many seasonal fishermen in the albacore tuna industry to lose their jobs.[79]

As ocean stakeholders, artisanal and small-scale fisherfolk are uniquely dependent on and knowledgeable about preserving a sustainable ocean. South Africa's Wild Coast — which has been the target of oil and gas companies and the site of ongoing legal challenges to proposed exploration activities, described above — hosts rock lobster, snoek, and other fish species critical to the livelihoods of deeply rooted communities whose cultures and histories are intrinsically tied

to small-scale fishing.[80] Exploration activities thus jeopardize not just the food security and livelihoods of fishing communities but also their spiritual and cultural connections to their coasts and oceans.[81]

The economic consequences of seismic air gun blasting are readily apparent in coastal areas across the US. In 2018, US President Donald Trump issued an executive order to expedite permitting for seismic air gun surveys. An economic analysis by Oceana found that allowing such blasting and subsequent offshore drilling activities along the East Coast of the US would threaten over 1.5 million jobs dependent on healthy ocean resources and nearly $108 billion in GDP while yielding less than 7 months' worth of oil and less than 6 months' worth of gas.[82] In contrast, according to Oceana, permanently protecting US coasts from new oil development could prevent over $720 billion in damages to people, property, and the environment — the equivalent of losing the entire economy of a major US city for a year.[83]

In addition to impacts on local livelihoods and biodiversity, offshore oil and gas exploration may threaten cultural resources and practices. In a landmark ruling in November 2022, Australia's Federal Court halted Santos's work on the Barossa gas project near the Tiwi Islands in the Timor Sea because the company had not properly consulted the Indigenous islanders.[84] The concerns of the Tiwi people were rooted in the potential impacts on their "sea country" — the marine environment that is crucial to their way of life and holds deep cultural significance.[85] Then, in September 2023, the federal court stopped oil and gas company Woodside from carrying out seismic blasting for a major gas project in the Scarborough gas field off the shore of Western Australia.[86] In its ruling, the court found that government authorities had erred in approving Woodside's plans despite the company's failure to properly consult the Traditional Custodians of the Murujuga (Burrup) Peninsula.[87] The area that would have been affected by the seismic blasts — which supports populations of leatherback turtles, great white sharks, and pygmy blue whales — carries great cultural and spiritual significance for the local Indigenous population, as Woodside itself has acknowledged.[88]

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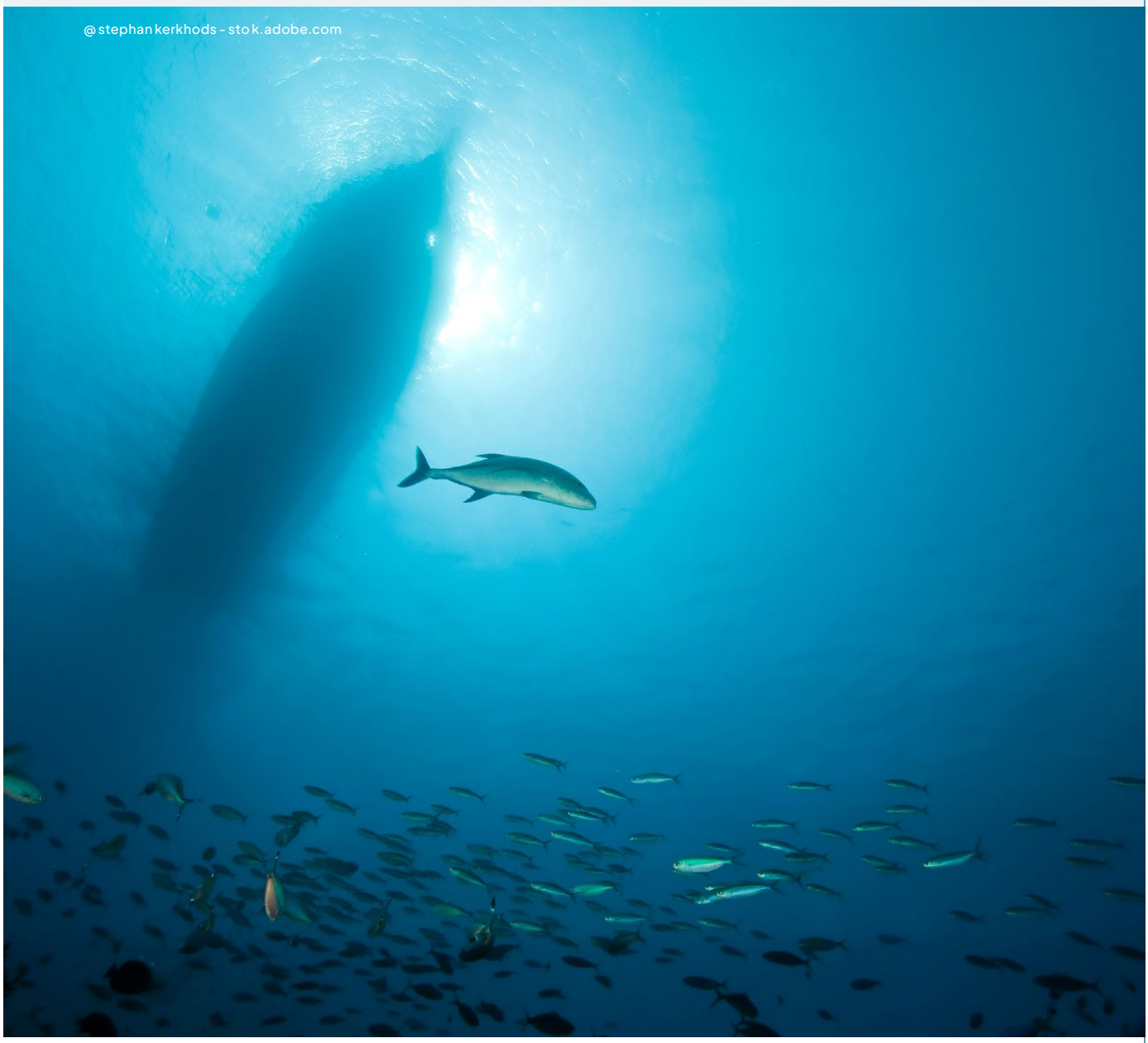
Conclusion

Exploration for offshore oil and gas poses many risks to oceans, their ecosystems, and the communities and climate that depend on them — whether or not it leads to commercial extraction and production of fossil fuels. While often ignored, the impacts of seismic testing, drilling, and waste disposal threaten marine life and the environment. Those impacts are only compounded when exploration leads to commercial extraction and production of oil and gas, which unleashes climate-destroying emissions at a massive scale. Exploration, dangerous in its own right, opens the door for more drilling and even more damaging consequences for the ocean, biodiversity, communities, and the climate. Those risks and impacts are explored further in the other briefs in the *Offshore, Off-Limits* series, which can be found on CIEL's website.



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