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Marine seismic surveys for hydrocarbon exploration: What's at stake?

Significance:

We argue that the immediate, intermediate, and long-term implications of seismic surveys for hydrocarbon exploration merit noting. If seismic surveys detect feasible hydrocarbon deposits, they effectively serve as a precursor to hydrocarbon extraction and consumption. The additional greenhouse gas emissions that will originate from new oil and gas fields in South Africa will push the world closer to the tipping point of breaching the limit of 1.5 °C targeted at the 2021 COP26 UN climate summit, and should thus be avoided at all costs. South Africa's pursuit of energy self-sufficiency through local fossil fuel extraction should not come at the cost of its unique biodiversity nor planetary health.

With a coastline extending approximately 3900 km, South Africa exercises jurisdiction over a vast Exclusive Economic Zone (EEZ) that exceeds 1.5 million km².¹ South Africa is located at an ecologically important crossroad for inter-ocean exchange of heat, salt and biota² involving the warm, fast-flowing Agulhas current of the Indian Ocean and the cold, nutrient-rich Benguela upwellings of the Atlantic Ocean, and within the range of influence of the world's most biologically productive ocean³, the Southern Ocean⁴⁻⁶. South Africa's marine territory is also characterised by spectacular topography, including dramatic canyons, slopes, plateaus, and seamounts.⁷ Unsurprisingly, South Africa's complex oceanographic influences, coastal topography, and geology boasts 179 marine ecosystem types, with 150 around South Africa and 29 in the country's sub-Antarctic territory.⁸ South Africa may also be richly endowed with hydrocarbon deposits.^{9,10} Seismic surveys are a routine and key upstream component of the hydrocarbon sector and crucial to understanding where recoverable oil and gas resources likely exist. Hydrocarbon extraction is largely dependent on seismic data acquisition and processing technology, with exploration companies relying on seismic survey results to decide whether or where to extract hydrocarbon deposits. While seismic surveys pose an immediate threat to South Africa's exceptionally rich marine life, the downstream implications of such surveys – the extraction and use of non-renewable energy sources – are more profound. Actively seeking new hydrocarbon deposits to exploit, thus contributing to already dangerously high levels of greenhouse gases (GHG) in the earth's atmosphere, poses an existential threat to most life on earth. Seen in this context, rationalising the boring of wells to exploit hydrocarbons in the name of energy sovereignty and security, is short-sighted, nationalistic, environmentally irresponsible, and morally indefensible. We, as a country, need to rethink this strategy.

What do we know about South Africa's marine life?

Approximately 13 000 species have been documented in South Africa's marine realms¹¹, including almost a quarter of global cephalopods (octopus, squid and cuttlefish)¹². With over 3800 species occurring nowhere else on earth¹³, South Africa ranks third in the world for marine species endemism¹². However, even these astonishing statistics may represent an incomplete picture as current knowledge of marine life in South African waters is limited and outdated.¹¹ For instance, coastal zone samples in South African waters were largely collected before 1980, primarily (83%) from depths shallower than 100 m.¹¹ More than 65% of South Africa's abyssal zone – which extends to 5700 m deep¹¹ – lies deeper than 2000 m. The abyssal plain in South African waters – where wells would ultimately have to be drilled to anchor rigs for hydrocarbon extraction – is completely unexplored and has not been surveyed for marine life.¹¹ Undoubtedly, many more species are yet to be discovered in South African waters.¹⁴ With the recent declaration in South Africa of an additional 20 offshore Marine Protected Areas (MPAs), 5.4% of the marine environment within the South African mainland EEZ is now protected, of which 3% is zoned as 'restricted' or 'no-take'.^{15,16} While admirable, this protection falls short of Goal 14.5 of the 2015 United Nations Sustainable Development Goals, which calls for the protection of a minimum of 10% of ocean ecosystems and habitats by 2020.¹⁷

Seismic surveys and potential harms

Short-term harms in the ocean

Marine seismic surveys are a key hydrocarbon exploration activity, and typically involve the use of airgun arrays that are towed behind vessels and produce high-intensity, low-frequency impulsive sounds at regular intervals. The sounds generated by seismic airguns can 'blanket' areas of up to 300 000 km² with noise¹⁸, have been recorded at locations up to 4000 km from the source¹⁹, and extend particularly well in deeper waters²⁰. Such robust findings refute claims by oil companies, such as Shell, that 'a buffer zone of 5 km' from a MPA constitutes an adequate risk mitigation measure.²¹ Seismic surveys are cause for concern for marine species reliant on sound for key life functions. Shell has argued that 'there is no evidence that any of [the 35 surveys conducted in South Africa have] caused any harm'²¹. Such arguments – encapsulated by the Latin phrase *Argumentum ad Ignorantiam* – capture the fallacy that a proposition is true simply on the basis that it has not been proven false or that it is false simply because it has not been proven true. Such misdirection is to be expected of a sector that is fighting to survive as the world rapidly transitions to greener energy sources. Contrary to what the hydrocarbon sector claims, there is ample evidence that seismic surveys detrimentally impact on a diverse range of marine species, including mammals, fish, invertebrates, plankton, and reptiles.^{18,19,22-27} In the African context, for example, seismic surveys have been found to negatively affect humpback whale singing activity off northern Angola.²⁸ The predominant

frequency range of seismic airgun emissions is within the detectable hearing range of most fish and elasmobranchs and can also elicit a neurological response in cephalopods and decapods.²⁵ The relative paucity of data in the South African context does not equate to no harm nor a low likelihood of harm.²⁹ Instead, it highlights a need for local research on the issue, including in relation to microbiota and meiofauna, which typically dominate benthic faunal biomass at abyssal depths and are essential for deep-sea ecosystem functions.³⁰ Further, the mere fact that seismic surveys have previously been conducted in South African waters does not establish irrevocable precedent, nor legitimise such activities in perpetuity.

We cannot assess potential thresholds of harm³¹ and mitigate associated risks if we have a poor understanding of *what* we could be harming and *how* different species suffer harm. While some international studies have found that seismic surveys have only a limited impact on demersal fish of commercial or recreational interest³², such results are not necessarily generalisable elsewhere given the array of heterogeneity across marine environments, both in terms of biota and physical characteristics. Nor can such results be extrapolated to other marine species. In assessing risk, we should consider the impact of seismic surveys on all marine life, including those in bathyal and abyssal environments. All species, regardless of commercial value, play a vital role in the ecosystem value chain. Because we do not currently know what the impact of seismic surveys could be in the South African context, the Precautionary Principle – which is a key tenet of South African environmental legislation and has been described as enabling decision-makers ‘to adopt precautionary measures when scientific evidence about an environmental or human health hazard is uncertain and the stakes are high’³³ – is warranted, in line with established international norms^{34,35}.

Long-term harms in the ocean

It would be short-sighted to only consider the immediate impact of seismic surveys. Downstream marine implications also bear noting. If seismic surveys detect feasible hydrocarbon deposits, they effectively serve as a precursor to hydrocarbon extraction and consumption. Climate change driven by fossil fuel extraction and consumption alter key factors that drive marine ecosystems, including winds, water temperatures, sea ice cover and ocean circulation.³⁶ Rising atmospheric CO₂ and the resulting increased oceanic CO₂ uptake is fuelling ocean acidification.^{37,38} Such changes in ocean temperature and chemistry may alter the physiological functioning, behaviour, biological interactions, and productivity of organisms, which, in turn, could lead to shifts in marine life size structure, spatial range, seasonal abundance, community structure and ecosystem function.³⁹ For instance, disruptions related to climate change will transfer nutrients from surface waters down into the deep ocean, leaving less at the surface to support plankton growth.⁴⁰ Such an outcome will have a knock-on effect on the entire ocean food chain. Studies show that sustained high levels of GHG emissions could suppress marine biological productivity for a millennium.³⁶ Left unchecked, such changes will ultimately destroy the fisheries and marine tourism industries of all countries, including South Africa, resulting in devastating job losses, food insecurity, and other adverse socio-economic consequences.^{41,42}

The Intergovernmental Panel on Climate Change (IPCC) has concluded with a degree of high confidence that climate change has caused substantial damages, and increasingly, irreversible losses, in terrestrial, freshwater and coastal and open ocean marine ecosystems.⁴² In its report published in February 2022, the IPCC noted that the extent and magnitude of climate change impacts are larger than estimated in previous assessments. The IPCC has concluded with a high degree of confidence that ‘...hundreds of local losses of species have been driven by increases in the magnitude of heat extremes, as well as mass mortality events on land and in the ocean’⁴¹. Despite incontrovertible evidence underscoring the harmful impact of fossil fuels on the oceans and the wider planet, given that the hydrocarbon sector has everything to lose if the world seeks alternative energy sources, unsurprisingly, the sector has, and will, continue to rationalise its relevance and downplay its detrimental impact on the planet.

What is at stake for the hydrocarbon sector?

Seismic surveys represent an upstream component of the hydrocarbon sector. The global seismic survey market registered a revenue of almost USD8 billion in the year 2020 and is forecast to pass USD11.5 billion by the end of 2030, growing at a compound annual growth rate (CAGR) of 3.96% during the forecast period.⁴³ The Middle East and Africa market is expected to attain the fastest growth globally, with a CAGR of 5.41% between 2020 and 2030.⁴⁴ With multiple exploration licences already approved in South Africa and other licence applications pending⁴⁵, South Africa represents a key emerging market for seismic surveyors. It would be fair to say that the cessation of offshore seismic surveys in South Africa represents an existential threat to the upstream seismic survey market locally and would undoubtedly undermine Africa’s projected market growth. Not surprisingly, given such vested interests, those who represent the seismic survey market have vociferously defended their sector against those urging caution.⁴⁶

The downstream constituents of the hydrocarbon sector, though, have considerably more to lose if we cease seismic surveys in South African waters. South Africa’s EEZ potentially holds nine billion barrels of oil, equivalent to 40 years of South African oil consumption, and natural gas deposits equivalent to 375 years of current South African gas consumption.⁹ The South African government has signalled its enthusiasm to exploit these resources by openly promoting the drilling of 30 hydrocarbon exploration wells off South Africa’s coast within a decade.⁴⁷ Besides the immediate risks to marine life that seismic surveys may hold, the exploitation of South Africa’s offshore hydrocarbon deposits also carry dire downstream implications.

Medium-term risks: Extraction

Beyond the serious occupational health and safety risks implicit in offshore hydrocarbon extraction⁴⁸, extraction activities also pose dire risks for the environment. In creating an enabling environment to give the hydrocarbon sector ‘the comfort to invest in this capital-intensive sector’, the South African government has committed to, amongst other measures, conducting ‘emergency response drills...to initiate the creation of a world-class oil spill response capacity in South Africa’ and operationalising the International Oil Pollution and Compensation Fund.⁹ While such measures may be touted as forward-thinking risk-mitigation measures, they also clearly illustrate that the government is under no illusion that offshore oil extraction, especially in South Africa’s notoriously rough waters, carries immeasurable risks for the country’s marine environment. The ocean circulation current of the Gulf of Mexico, which hosts numerous oil and gas rigs, moves up to 2 m/s, strong enough to severely damage the steel infrastructure of oil and gas rigs.⁴⁹ The Agulhas current along the eastern seaboard of South Africa has also been measured to flow at 2 m/s⁵⁰, a close second only to the Gulf Stream, which is considered the world fastest ocean current at approximately 2.5 m/s⁵¹. But the Agulhas current is remarkable for its strength⁵², transporting up to 122.9 Sv. (122.9 million m³/s), with an average of 69.7 Sv.⁵³, significantly more than the Gulf Stream, which transports approximately 30 Sv.⁵⁴ In 2014, French energy company, Total, had to abandon its deep-sea exploration off South Africa’s east coast because rough seas damaged its rig^{55,56}, underscoring the risks implicit in drilling off South Africa’s coast. ‘Rogue waves’ – waves that are abnormally large and unpredictable – occur with relative frequency off South Africa’s east coast.⁵⁷⁻⁶¹ Rogue waves merit concern as they have been implicated in damaging oil and gas platforms in the open sea, including the North Sea’s Draupner oil platform.⁶² The massive release of crude oil from the breach of the Deepwater Horizon rig in the Gulf of Mexico⁶³ offers a sobering example of the devastating impact the release of a contaminant can have on ecosystems. These case studies collectively highlight the risks of sinking wells in oceans with abnormally high waves and strong currents, and how an oil spill from an offshore industrial accident in such conditions could devastate South Africa’s exceptional coastline and sensitive marine ecosystems over a wide area, in a short time. Attempted damage control after the fact is no comfort when we can stop the possibility of an accident even occurring by not sinking wells in our EEZ. Prevention is better than cure. Seismic



surveillance and extraction risks aside, furtive emissions (unintentional leakage and discharge) resulting from the extraction of hydrocarbons^{64,65} and the associated GHG from hydrocarbon consumption itself poses the greatest risk to our planet.

Long-term risks: Breaching the tipping point for planetary health

GHGs have a detrimental impact on human health^{66,67} and on the planet⁶⁸. In 2021, the International Energy Agency, of which South Africa is an associate member, noted⁶⁶:

The energy sector is the source of around three-quarters of greenhouse gas emissions today and holds the key to averting the worst effects of climate change, perhaps the greatest challenge humankind has faced. Reducing global carbon dioxide (CO₂) emissions to net zero by 2050 is consistent with efforts to limit the long-term increase in average global temperatures to 1.5 °C. This calls for nothing less than a complete transformation of how we produce, transport and consume energy. [our emphasis]

This warning echoes earlier evidence that showed that only a sharp and rapid decline in fossil fuel use will keep the world's temperature increase below 1.5 °C.^{69,70} If we have any hope of keeping within a 1.5 °C 'carbon budget', by 2050 nearly 60% of oil and fossil methane gas and 90% of coal must remain unextracted.⁷¹ Emissions do not respect borders. Humanity cannot achieve this collective goal if South Africa does not do its fair share. In February 2020, South Africa adopted a Low Emissions Development Strategy.⁷² In September 2021, South Africa announced its intention to limit GHG emissions to 398–510 metric tons of CO₂ equivalent (MtCO₂e) by 2025, and to 350–420 MtCO₂e by 2030.⁷³ While such commitments on paper are welcomed, they are incompatible with the government's open and vociferous support for hydrocarbon exploitation, evidenced by the publication of a draft Upstream Petroleum Resources Development Bill at the end of 2019⁷⁴, government's siding with the oil sector in court against concerned communities and environmentalists^{75–77}, and the Department of Mineral Resources and Energy (DMRE) pursuance of a 'gas master plan'⁷⁸. The present MRE Minister's unflinching support of the oil and gas sector⁷⁹ and his attacks on those who oppose seismic surveys or simply ask inconvenient questions related to his portfolio, are also well documented⁸⁰. Such factors raise the question of whether today's politicians are prepared to gamble the interests of future generations and the planet's sustainability for local, short-term gain.

Stemming the unfolding climate change emergency will require immediate action. On paper, South Africa has made changes towards the sustainable management of its marine habitats, such as becoming a signatory to the Convention on the Conservation of Migratory Species of Wild Animals (CMS)⁸¹ and declaring additional MPAs in 2019⁸². These commitments require an accompanying meaningful change in policies and standard operating procedures. For example, Resolution 12.14 of the CMS (adopted in 2017)⁸³ mandates full environmental impact assessments before starting any noise-emitting operations that may negatively impact marine life. Given the promulgation of the additional 20 MPAs¹⁵, the proven impact of seismic surveys^{18,19,22–27}, and our international obligations under the CMS, the Scientific Advisory Group on Emergencies (SAGE) recommends that all exploration applications approved before 28 June 2018, should be subject to environmental authorisation. Such review must be objective and robust. To not do so on the basis of 'transitional arrangements'⁸⁴ – a legal loophole to avoid 'red tape' – constitutes a moral wrong and suggests that our government's commitment to a sustainable future is mere lip service. But beyond robust environmental authorisation for upstream hydrocarbon activities, we need to consider the big picture. Hydrocarbon seismic surveys are a harbinger of GHGs. As South Africa is already one of the world's largest contributors of GHGs⁸⁵, the country needs to do its fair share to help reduce GHGs. To do so, the South African government needs to urgently rethink its long-term energy security strategy.

The cost of transitioning to a net-zero emission economy by 2050

In October 2019, South Africa published its revised Integrated Resource Plan (IRP), which outlines the country's future energy strategy.⁸⁶ The IRP notes that South Africa's energy sector contributes approximately 80% of the country's total greenhouse gas emissions, of which 50% are from electricity generation and liquid fuel production alone.⁸⁶ Disappointingly, despite South Africa's tremendous renewable energy potential, the 2019 IRP outlines new investments in hydrocarbon-based energy sources – including an additional 1500 MW of coal-to-power capacity – and sets an artificial limit of 33% of South Africa's energy needs to be met by renewables by 2030.⁸⁶ This counterintuitive strategy suggests that political and vested interests are impeding South Africa's renewable energy potential. Aside from the hydrocarbon sector supporting approximately 248 000 jobs in South Africa (directly, indirectly or through induced impact) – which equates to 1.5% of South African employment⁸⁷ – fossil fuels are also an important source of government revenue. In 2019–2020, South African taxes on fossil fuel consumption, production, and incomes amounted to approximately ZAR100.5 billion (2% of South Africa's GDP and 7.4% of general government revenue).⁸⁸ However, such revenue is discounted by significant government bailouts for state enterprises that are heavily dependent on fossil fuels, such as the South African Airways.⁸⁸ Revenue from fossil fuels is also dwarfed by the estimated ZAR172 billion in energy subsidies gifted by the government in the 2020/2021 financial year alone.⁸⁸ If one factors in government expenditure through bailouts to the state-owned energy company, Eskom (which further distorts the price of electricity generated from coal), government revenue from fossil fuels is rendered insignificant.⁸⁸ In fact, once the social costs of fossil fuels (climate change and air pollution related deaths and lost working days from fossil fuel combustion) are factored in – which are estimated to be at least five times higher than fossil fuel revenues – the net annual cost to society of fossil fuels is approximately ZAR550 billion.⁸⁸ The planned retirement of coal-fired power stations, technological changes (such as drops in the cost of green energy sources and rapid progress in energy storage), new energy market regulation, available finance, and geopolitics, will significantly impact on South Africa's ability and appetite to continue pursuing a hydrocarbons-centred economy. Seen in this light, South Africa should be moving away from fossil fuels as fast as possible. This necessity will prove costly.

South Africa's 'transition risk' – the cumulative impact to South African asset prices and revenues of transitioning to a low-carbon economy, in line with the country's international commitments, has been estimated at approximately USD125 billion (ZAR1.8 trillion in 2019 value terms) by 2035.⁸⁹ For South Africa to achieve its target of transitioning to a net-zero emission economy by 2050, the country will require an investment of ZAR887–1173 billion.⁹⁰ To optimally reduce emissions, South Africa may require aggregate new capital expenditure of up to ZAR2.9 trillion by 2050.⁹⁰ South Africa cannot achieve these goals without international support and has requested a minimum of USD8 billion support per year by 2030, with a view to equally distributing funding between adaptation and mitigation.⁹¹

Moral responsibility and international solidarity

As developed countries have historically been responsible for the majority of GHG emissions^{92,93}, they have committed to providing financial resources to assist developing countries meet their mitigation and adaptation obligations⁹⁴. In November 2021, the governments of South Africa, France, Germany, the United Kingdom and the United States of America, along with the European Union, announced a long-term 'Just Energy Transition Partnership' to support South Africa's decarbonisation efforts.⁹⁵ The partnership will mobilise an initial commitment of USD8.5 billion for the first phase of financing through various mechanisms including grants, concessional loans and investments and risk sharing instruments.⁹⁵ The Partnership aims to prevent up to 1–1.5 gigatonnes of emissions over the next 20 years and support South Africa's move away from coal and its accelerated transition to a low emission, climate resilient economy. While this initiative is a welcome



first step, such assistance will have to be sustained for countries such as South Africa to transition to a net zero economy by 2050. Such support will be more forthcoming if South Africa's next IRP commits to ambitious green energy targets – at least 50% of South Africa's energy needs should come from renewable sources by 2030 – and government aggressively pursues its realisation.

Conclusion

Safeguarding and strengthening our natural systems is crucial to securing a liveable future. Marine seismic surveys for the hydrocarbon industry are effectively a harbinger of additional GHGs. If today's politicians fail to act as responsible stewards of our environment and resources for the sake of future generations and the long-term sustainability of our planet, concerned communities, civil society actors, environmentalists, and scientists have a moral obligation to speak out. South Africa is highly vulnerable to the impacts of climate change, so should do everything in its power to avert a rise in GHG emissions. While gas has been touted as a 'transition' energy source, investing in new gas infrastructure will unnecessarily lock South Africa into fossil fuel energy consumption for decades. Further, because such investments will take decades to recuperate, vested interests will ensure that these facilities are used for their full lifetimes or beyond, which will only delay the switch to renewable energy sources. Such an opportunity cost is economically, environmentally, and morally unacceptable. South Africa's cabinet should signify its unequivocal commitment to the sustainability of the planet by aggressively decarbonising its power sector, not unnecessarily prolonging its lifespan for as long as possible, or worse, ramping it up. It is time for the country to address its ambition gap and transition to a net-zero emission economy as soon as possible. Moreover, cabinet should review all offshore exploration licences already awarded, in light of South Africa's declaration of additional MPAs. The additional GHG emissions that will originate from new oil and gas fields in South Africa (inland and offshore), will push the world closer to the tipping point of breaching the limit of 1.5 °C targeted at the 2021 COP26 UN climate summit, and should thus be avoided at all costs. Instead, South Africa should harness its impressive scientific and technical capacity to develop and harness sustainable, renewable energy sources, in line with the country's vast potential. South Africa's pursuit of energy self-sufficiency through local fossil fuel extraction should not come at the cost of its unique biodiversity, nor planetary health. Energy security should be based on science, not narrow, short-sighted political and vested interests. History will judge the current South African government harshly if it fails to act decisively now for the sake of its people and the greater good of the planet.

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Competing interests

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