Deep-sea mining - is it worth it?

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The main consensus among scientists is that global warming is upon us and the urgent need to tackle this problem. The goal set to be achieved by the UN is to prevent global warming by more than 1.5 degrees by 2100 (UNFCCC, 2022). All can agree on the need for a green revolution. How do we switch to a green revolution? The best alternatives are wind, water, and solar energy, though there are problems arising if they are adapted on a larger scale. Nonetheless, these alternatives could potentially lift the burden off our energy demand. Do we have enough resources to invest and build on greener technologies to solve global warming? Are there any alternatives besides these and are they sustainable? This paper will examine the option of deep-sea mining and the risks it includes.

Windmills, solar panels and watermills require different metals for generating electricity and for power storage. These metals are often referred to as Rare Earth Elements (REE). Some of the minerals that are under the REE umbrella are cobalt, lithium, copper, manganese. REE can be extracted from the earth in massive open land-based mines. Some countries like China, Russia, USA, Chile and the Democratic Republic of the Congo, are the main holders of these valuable resources. Yet in recent years, the interest in land-based mining has shifted, and has been redirected to the sea. People have known about minerals on the ocean floor since clumps of iron have been caught in fishing nets in 1860 (Lodge, 2017). However, it has been proven very difficult to extract the minerals from the seabed and so there is still an abundance of minerals, especially in developing countries (Lodge, 2017).

Deep-sea mining is a controversial topic of discussion across many fields of research. It is the extraction of minerals below 200 meters in the sea, primarily harvesting three types of deposits: polymetallic nodules, polymetallic sulphides and cobalt crusts. Mining can cause significant damage to the sea floor as the machines are destroying it, and the habitat may never fully recover from it. Another issue is the sediment plumes that arise from crust mining of cobalt. Organisms can be affected by the plumes, like sponges and corals, by clogging their pores, which are crucial for the organisms' survival. The resources and their effects on the marine environment will be analysed in the following.

Potential marine resources

There are three main resources that are commercially attractive in deep sea mining: Manganese Nodules (MN), Seafloor Massive Sulphides (SMS) and Cobalt-Rich Crusts (CRC). Manganese nodules (MN) form on vast deep-water abyssal plains and comprise primarily of manganese and iron. These nodules are potato-like in shape, 4–10 cm in diameter (Blöthe et al., 2015). Very few studies have investigated nodule fauna because of their inaccessibility on the abyssal plains, but they have been reported to provide some of the only hard substrate for marine species at those locations. Therefore, their removal may result in significant habitat loss (Vanreusel et al., 2016). In fact, densities of both sessile and mobile fauna living on or near manganese nodules are higher than in nodule-free areas of the abyssal plains (Vanreusel et al., 2016). The second category of interest is Seafloor massive sulphides (SMS), which are normally around hydrothermal vents. SMS have a high sulphide content and are also rich in copper, gold, zinc, lead, barium, and silver (Hein et al., 2013). Hydrothermal vents are characterized by temperatures up to 400◦C and high acidity levels (pH 2–3), yet they support vast communities of organisms (Ramirez-Llodra et al., 2007). Chemosynthetic bacteria form the basis of vent ecosystems, and in turn support a large biomass of invertebrates that include molluscs, annelid tube-dwelling worms, and crustaceans (Van Dover et al., 2002). Moreover, around 85% of vent species are considered to be endemic (Ramirez-Llodra et al., 2007).

Cobalt-rich crusts (CRC) is the third and last category, formed on the slopes and summits of seamounts. CRC contain manganese, iron and a wide array of trace metals including cobalt, copper, nickel and platinum (Hein et al., 2013). In addition, seamounts are described as oases on the abyssal plains, because they often support higher epibenthic species diversity and biomass than nearby slopes (Rowden et al., 2010). Seamounts have been shown to support high levels of primary productivity and provide a habitat for pelagic species, fish and marine mammals, that are known to aggregate over seamounts, using them either for foraging or resting (Garrigue et al., 2015).

The vast deep-sea environment is yet to be explored and it remains a mystery. Depending on the nature, scale and location of proposed deep sea mining activities, many serious and widespread negative impacts on biodiversity are inevitable and likely to be irreversible (Van Dover et al., 2017). Not to mention that, some long-living species are vulnerable to physical disturbance caused by the mining, because of their slow growth rates (Carreiro-Silva et al., 2013). Mitigation techniques have been proposed to monitor the potential impacts to biodiversity. Nonetheless, we do not know how to mitigate impacts or restore deep-sea habitats successfully so far (Van Dover, 2014; Van Dover et al., 2017).

Sound pollution

Large-scale deep-sea mining has negative effects on fish and marine mammals in great distances. The noise and vibrations are generated from the operating equipment on the seafloor and from the mining vessels at the surface (Koschinsky et al., 2018). Sound underwater resonates differently than on the land. Water is denser than the air, which causes sound to resonate 4,8 times faster in water. Besides, it is very important to distinguish between sound and vibration. Sound is the “noise” of an organism or of an object, generated by movement of either. While vibration refers to the movement of the sound source (Popper and Hawkins, 2019). Noise and vibration travels far under-water and will thereby affect organisms who are further away from the sound source (Hildebrand, 2004).

Recent research has shown that anthropogenic sound in the sea causes an increase in stress, disrupts communication, navigation, provokes avoidance behaviour and interferes with prey detection, predator avoidance and even mating for fish and marine mammals (Buscaino et al., 2010a; Nabi et al., 2018; Popper and Hawkins, 2019; Guh, Tseng and Shao, 2021a). Several studies have shown that fish under short term exposure of vessel noise show a measurable stress response (Buscaino et al., 2010b; Celi et al., 2016). Long-term exposure in fish and marine mammals will affect the reproductive system and their survival in total. Different species communicate through sound when attempting to mate. Thus a disruption or distortion of the noise will have consequences for the mating process itself (Nabi et al., 2018; Popper and Hawkins, 2019). In spite of the research conducted to this day, we cannot fully assess the effects of sound on marine invertebrates or other species (Jézéquel, Bonnel and Chauvaud, 2021).

The complexity

The abovementioned short- and long-term environmental impacts are strongly related to the Sustainable Development Goal (SDG) No. 14, Life Below Water. It is one of the SDGs that were implemented by the United Nations in 2015. Nevertheless, the deep-sea mining industry would especially conflict with Target 14.1 (reduce marine pollution of any kind) and 14.2 (protect marine ecosystems), whereas increased scientific knowledge, research and technology (target 14.A) and further implementation of international sea law (target 14.C) are needed to assess and deal with all the direct and indirect consequences of deep-sea mining. It is also notable to highlight that metals and minerals for renewable energy technologies like wind turbines, solar panels, electric vehicles and batteries, are highly abundant on the seafloor in several regions around the world (Hein et al., 2013; International Seabed Authority, 2022).

Retrieving these metals would contribute positively to SDG7 (Clean Energy) and at the same time to SDG13 (Climate Action), by reducing the CO2 emissions of the electricity and transportation sector. Moreover, many studies have proved that the carbon footprint of terrestrial mines is significantly higher than the deep-sea mining (TGS 2022). Additionally, land-based mines in many cases pollute the ground and surface water through toxic waste, while sustaining unhuman working conditions like child labour in Third-World countries (Financial Times, 2019). Deep-sea mining would release the pressure from the land-based mining and therefore positively affect SDG15 (Life on Land) and SDG8 (Decent Work and Economic Growth) with better working conditions.

The emergence of a whole new industry of deep-sea mining promotes using the already existing infrastructure of oil extraction (Haji and Slocum, 2019), aiding SDG9 (Industry, innovation and infrastructure) by sustaining resources. Last but not least, all of the sites of interest for seafloor mining are in international waters, which virtually are beyond national jurisdiction (Watzel et al., 2020). The SDG17 (Partnership for the Goals) is a necessity for an international and interdisciplinary approach, to ensure evenly distributed potential profit and risks for all countries. This procedure will demand collaborative research, exploration and assessment of possibilities and challenges of deep-sea mining, especially on Small Island Developing States (SIDS), who are often located in the same geographical regions as potential mining sites.

Conclusion and discussion

Deep-sea mining has a lot of risks, but can provide us with the resources we need. The risks involved are the unknown effects to biodiversity, uncertainty for the full recovery of habitats, increase in stress levels, migration, reproduction patterns, interference with prey detection, disruption of communication and more, from the operating machinery. Currently however, we do not have enough of the supplies needed for a greener revolution to solve global warming. Does that justify the destruction of a habitat that yet has to be discovered? Not necessarily. Even if we mine the bottom of the sea, that does not imply we solve global warming. Not to mention, further collaborative research must be conducted and agreed upon with all countries worldwide. Which is one of the hardest things to do, given the differences between national jurisdiction laws.

To conclude, deep-sea mining offers the option to reduce CO2 emissions and release the pressure off the land-based mining sites. Perhaps if we calculate all the consequences and discover a way to reduce the damage on the seabed, it would be a sustainable solution. Nonetheless, it is necessary to follow the SDG Agenda, without harming any of its goals if possible. Lastly, we should consider deep-sea mining, but only as the last resort.

References

Blöthe, M., Wegorzewski, A., Müller, C., Simon, F., Kuhn, T., and Schippers, A. (2015). Manganese-cycling microbial communities inside deep-sea manganese nodules. Environ. *Sci. Technol*. 49, 7692–7770. doi: 10.1021/ es504930v

Buscaino, G. *et al.* (2010a). 'Impact of an acoustic stimulus on the motility and blood parameters of European sea bass (Dicentrarchus labrax L.) and gilthead sea bream (Sparus aurata L.)', *Marine environmental research*. Mar Environ Res, 69(3), pp. 136–142. doi: 10.1016/J.MARENVRES.2009.09.004.

Carreiro-Silva, M., Andrews, A., Braga-Henriques, A., de Matos, V., Porteiro, F. M., and Santos, R. S. (2013). Variability and growth of long-lived black coral *Leiopathes* sp. from the Azores. Mar. *Ecol. Prog. Ser*. 473,. 189–199 doi: 10.3354/meps10052

Celi, M. *et al.* (2016). 'Vessel noise pollution as a human threat to fish: assessment of the stress response in gilthead sea bream (Sparus aurata, Linnaeus 1758)', *Fish Physiology and Biochemistry*. Springer Netherlands, 42(2), pp. 631–641. doi: 10.1007/s10695-015-0165-3.

Financial Times (2019). Congo, child labour and your electric car. Retrieved 15 May, 2022 from https://www.ft.com/content/c6909812-9ce4-11e9-9c06-a4640c9feebb.

Garrigue, C., Clapham, P. J., Geyer, Y., Kennedy, A. S., and Zerbini, A. N. (2015). Satellite tracking reveals novel migratory patterns and the importance of seamounts for endangered South Pacific humpback whales. R. Soc. *Open Sci.* 2:150489. doi: 10.1098/rsos.150489

Guh, Y. J., Tseng, Y. C. and Shao, Y. T. (2021a). 'To cope with a changing aquatic soundscape: Neuroendocrine and antioxidant responses to chronic noise stress in fish', *General and Comparative Endocrinology*. Academic Press Inc., p. 113918. doi: 10.1016/j.ygcen.2021.113918.

Guh, Y. J., Tseng, Y. C. and Shao, Y. T. (2021b). 'To cope with a changing aquatic soundscape: Neuroendocrine and antioxidant responses to chronic noise stress in fish', *General and comparative endocrinology*. Gen Comp Endocrinol, 314. doi: 10.1016/J.YGCEN.2021.113918.

Haji, M., Slocum, A. (2019). An offshore solution to cobalt shortages via adsorption-based harvesting from seawater. Renewable and Sustainable Energy Reviews,Volume 105, pp. 301-309, ISSN 364-0321. Retrieved May, 9, 2022, from https://doi.org/10.1016/j.rser.2019.01.058.

Hein, J., Mizell, K., Koschinsky, A., and Conrad, T. (2013). Deep-ocean mineral deposits as a source of critical metals for high- and green-technology applications: comparison with land-based resources. *Ore Geol. Rev*. 51, 1–14. doi: 10.1016/j.oregeorev.2012.12.001

Hildebrand, J. (2004). *Sources of Anthropogenic Sound in the Marine Environment*, *mmc.gov*. London, England. Available at: https://www.mmc.gov/wp-content/uploads/hildebrand.pdf (Accessed: 11 May 2022).

International Seabed Authority (ISA) (2022). Exploration areas. Jamaica. Retrieved May, 13, 2022, from Exploration areas | International Seabed Authority (isa.org.jm).

Jézéquel, Y., Bonnel, J. and Chauvaud, L. (2021). 'Potential for acoustic masking due to shipping noise in the European lobster (Homarus gammarus)', *Marine Pollution Bulletin*. Elsevier Ltd, 173(Pt A). doi: 10.1016/j.marpolbul.2021.112934.

Koschinsky, A. *et al.* (2018). 'Deep-sea mining: Interdisciplinary research on potential environmental, legal, economic, and societal implications', *Integrated Environmental Assessment and Management*. Wiley-Blackwell, pp. 672–691. doi: 10.1002/ieam.4071.

Lodge, M. (2017). The International Seabed Authority and Deep Seabed Mining, United Nations. Retrieved May 9, 2022, from https://www.un.org/en/chronicle/article/international-seabed-authority-and-deep-seabed-mining.

Nabi, G. *et al.* (2018). 'The possible effects of anthropogenic acoustic pollution on marine mammals' reproduction: an emerging threat to animal extinction', *Environmental Science and Pollution Research*. Springer Verlag, 25(20), pp. 19338–19345. doi: 10.1007/s11356-018-2208-7.

Popper, A. N. and Hawkins, A. D. (2019). 'An overview of fish bioacoustics and the impacts of anthropogenic sounds on fishes', *Journal of Fish Biology*. Blackwell Publishing Ltd, pp. 692–713. doi: 10.1111/jfb.13948.

Ramirez-Llodra, E. Z., Brandt, A., Danovaro, R., De Mol, B., Escobar, E., German, C. R., et al. (2010). Deep, diverse and definitely different: unique attributes of the world's largest ecosystem. *Biogeosciences* 7, 2851–2899. doi: 10.5194/bg-7-2851-2010

Ramirez-Llodra, E., Shank, T. M., and German, C. R. (2007). Biodiversity and biogeography of hydrothermal vent species: Thirty years of discovery and investigations. *Oceanography* 20, 30–41. doi: 10.5670/oceanog. 2007.78

TGS (2022). Deep Sea Minerals. Retrieved May, 10, 2022 from https://www.tgs.com/our-data/deep-sea-minerals.

UNFCCC - United Nations Framework Convention on Climate Change (2022). The Paris Agreement. Retrieved 15 May, 2022 from https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.

Van Dover, C. L. (2014). Impacts of anthropogenic disturbances at deep-sea hydrothermal vent ecosystems: a review. Mar. *Environ. Res*. 102, 59–72. doi: 10.1016/j.marenvres.2014.03.008

Van Dover, C. L., Ardron, J. A., Escobar, E., Gianni, M., Gjerde, K. M., Jaeckel, A., et al. (2017). Biodiversity loss from deep-sea mining. *Nat. Geosci.* 10, 464–465. doi: 10.1038/ngeo2983

Van Dover, C. L., German, C. R., Speer, K. G., Parson, L. M., and Vrijenhoek, R. C. (2002). Evolution and biogeography of deep-sea vent and seep invertebrates. *Science* 295, 1253–1257. doi: 10.1126/science.1067361

Vanreusel, A., Hilario, A., Ribeiro, P. A., Menot, L., and Arbizo, P. M. (2016). Threatened by mining, polymetallic nodules are required to preserve abyssal epifauna. *Sci. Rep*. 6:26808. doi: 10.1038/srep26808

Watzel, R., Rühlemann, C.,and A.Vink (2020). Mining mineral resources from the seabed: Opportunities and challenges. Marine Policy, Volume 114, ISSN 0308-597X, https://doi.org/10.1016/j.marpol.2020.10382.