Deep-sea mining: the ecosystems at risk and potential impacts

Fragile deep-sea ecosystems are already faced with numerous stressors, including pollution, climate change, and extractive activities (Pinheiro et al., 2023). Deep-sea mining is emerging as a new threat to our ocean as scientists warn of potentially inevitable widespread and permanent damage to ecosystems and biodiversity (Deep-sea mining science statement, 2023).

The International Seabed Authority (ISA) is the regulatory body that would control any deep-sea mining in the international areas of the ocean, if the industry were to proceed. To date, the ISA has granted 31 exploration contracts and is currently discussing regulations with a view to opening the international seabed to industrial-scale mining (International Seabed Authority, 2023).

There are three broad types of deep-sea habitats where mineral-rich deposits are found and which are therefore threatened by deep-sea mining: nodule-rich abyssal plains; ferromanganese-encrusted seamounts; and hydrothermal vents.

Habitats threatened by deep-sea mining

Abyssal plains
Abyssal plains are extensive, flat, sediment-covered regions of the deep that make up 75% of the seafloor and support high levels of biodiversity, ranging from octopuses to sea urchins to fishes (United Nations, 2021). Slow-growing polymetallic nodules are found on some of these plains, where they form an integral part of the ecosystem, provide attachment sites for the majority of species, and are essential for the integrity of food-webs. Roughly the size of ping-pong to tennis balls, the nodules contain nickel, copper, cobalt, and other minerals that have precipitated around fish teeth, sediment, or other small objects over millions of years. The nodules are spread in varying concentrations across the seafloor at depths between 3,000 and 6,000 meters (Stratmann et al., 2021).

Prospective mining companies propose to use hydraulic suction via remotely operated tractors to strip-mine nodules on the seafloor and then pump them through a series of pipes called ‘risers’ up to collector ships on the sea surface.

Each individual operation is expected to effectively mine roughly 15,000 square kilometers of the seafloor over a 30-year contract period (Lodge, 2018). In the Clarion Clipperton Zone (CCZ), where deep-sea mining could first begin, some industry projections are to directly mine seafloor habitats over a total area of half a million square kilometers, with indirect effects - such as sediment plumes, wastewater discharge and noise pollution - impacting 1.5 million square kilometers. The size of the footprint would be similar to the size of Spain,
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Portugal, France, Belgium and Germany combined (Smith et al., 2020; Amon et al., 2022). A separate report highlights that the total biosphere impacted by nodule mining in abyssal plains alone would be up to 25-75 million cubic kilometers, more than the volume of all freshwater in the world (Planet Tracker, 2023).

The proposed scale of the operations has led many scientists to conclude that biodiversity loss would be unavoidable and irreversible on multi-generational timescales (Niner et al., 2018). A recent study concluded that over 90% of the species observed within the CCZ are currently undescribed by science, highlighting just how little we know about deep-sea ecosystems (Rabone et al., 2023).

Impacts: Mining of the nodules would involve disruption and destruction of the substrate and seabed, leading to the loss or extinction of species, as well as fragmentation or loss of ecosystems. Scientists estimate that the nodules and nodule-dependent animals, which are over 50% of species in the CCZ and include Casper octopuses, may take millions of years to recover, if at all (Purser et al., 2016). Their removal could potentially lead to an “irreversible loss of some ecosystem functions.” (Simon-Lledó et al., 2019)

Mining would disturb sediments on the seafloor, creating plumes of suspended particles. It is currently unknown how far these particles may disperse beyond the mining area, and whether they would smother or otherwise damage marine life in areas beyond the actual mining sites. However, modelling suggests that the plumes could cover an area several tens of thousands of square kilometers beyond mining sites, with sediment levels in the water far exceeding the amount that animals in the area have adapted to (Midas Project, 2013). This would particularly impact filter feeders such as corals and sponges.

Discharge plumes comprising wastewater, sediment, and residual nodule material, would be dumped back into the ocean from the collector ships. These may cause additional plumes that could spread hundreds of kilometers or more throughout the water column at varying concentrations, impacting species inhabiting the water column at various depths (Drazen et al., 2020). Increasing turbidity or cloudiness of the water could impact species that use bioluminescence to communicate. This could harm the filter feeding apparatuses and gills of animals and increase stress hormone levels. In addition, residual metals and other compounds in the wastewater could prove toxic to some forms of marine life and could get into the marine food chain (Van der Griet & Drazen, 2021).

Noise and light pollution could significantly disrupt species, such as birds, turtles, whales, and deep-dwelling animals that use sound, echolocation or bioluminescence to communicate (OceanCare, 2021). Scientists warn that this “critical source of potential environmental harm is understudied and largely overlooked.” (Williams et al., 2022)

Risks to ecosystem services such as climate regulation. Carbon sequestration and storage will likely be impacted. Studies have found that carbon cycling within abyssal plain ecosystems remains reduced 26 years after simulated deep-sea mining operations (Stratmann et al., 2018).

Seamounts

Seamounts are underwater volcanic mountains teeming with life that rise more than a thousand meters from the seabed. There are estimated to be tens of thousands of seamounts worldwide. Providing food and habitat for many species, they are among the world’s most important and vulnerable ecosystems. Productivity on seamounts is high both at the seafloor and in the overlying and surrounding waters. Seamounts are therefore recognized as biodiversity hotspots both for open-ocean species, such as whales, seabirds, turtles, and migratory species of fish, and for deep-sea corals and sponges, which in turn serve as homes for other residents of the deep (Watling & Auster, 2017; Derville et al., 2020).

Some seamounts have rock surfaces on which cobalt and other metals have accumulated over tens of millions of years, with the richest deposits found at depths of between 800 and 2,500 meters. It takes a million years for a crust of up to six millimeters to form. These cobalt-rich crusts are a target for deep-sea mining (Weaver et al., 2018).
The mining technology is still under development, but one proposal is for large bottom-crawling vehicles to use articulated cutters to fragment the crust, while others suggest it can be separated from the rock through water jet stripping, chemical leaching, or sonic separation (Qiao et al., 2021).

**Impacts:** The proposed mining methods are expected to destroy the bottom habitat and ecosystems of seamounts. They would also impact species in the water column and at the sea surface through sediment plumes, noise and light generated by mining operations.

**Hydrothermal vents**

Active hydrothermal vents are where superheated, chemical-laden water is forced from the Earth's crust. They are found on seafloor volcanoes and ridges that form along the edges of tectonic plates, such as the Mid-Atlantic Ridge, an underwater mountain range extending from the Arctic to Antarctica. Deep-sea vent systems not only support some of the most unique ecological communities known to science, they also form chimney-shaped ore deposits with significant concentrations of metals including gold, silver, copper and zinc. Hydrothermal vents are unique because they do not derive their energy through photosynthesis from light, like most life forms, but from chemicals in vent fluids. The inhabiting animals are very abundant and mostly endemic. The uniqueness of these ecosystems has led a multidisciplinary group of prominent deep-sea vent scientists, sociologists, geologists, conservationists and legal experts to call for a ban on mining active hydrothermal vents (Van Dover et al., 2018).

Sometimes venting no longer occurs, resulting in inactive or extinct hydrothermal vents. These are home to unique microbial communities and fauna such as corals and sponges. These ecosystems are poorly documented and the animals living there are often poorly-known and/or entirely new to science (Van Dover et al., 2018).

**Impacts:** If mining on hydrothermal vents were to go ahead, the diversity of life they support, with their unique features and adaptations to the extreme environment, would be lost. Mining hydrothermal vents would destroy vent habitats and kill the associated organisms before the biodiversity of these unique and fragile ecosystems is well understood. Scientists have found that almost two-thirds of the mollusc species unique to vent habitats would be threatened with extinction if deep-sea mining occurs, with more than 20% listed as critically endangered (Thomas et al., 2021). In addition, hydrothermal vents may play an important role in climate regulation, thus their destruction could impair this critical service (Levin et al., 2016; Ardyna et al., 2019).

**Scientists’ concerns over deep-sea mining**

Concerns that the risks associated with deep-sea mining outweigh any potential net benefits for humankind are being raised by governments, politicians, the scientific community, the fishing industry, leading businesses, banks and financial institutions, and civil society (Deep Sea Conservation Coalition, 2022). The scientific community considers that deep-sea mining risks causing irreversible environmental and ecological impacts, resulting in the loss of ecosystem services, habitats, and species (Jones et al., 2018). They also warn of the climate risks of deep-sea mining and the “uncertain impacts on carbon sequestration dynamics and deep-ocean carbon storage, as well as impacts to ecosystem services more broadly.” (Deep-sea mining science statement, 2023)

Dr. Diva Amon, marine biologist and researcher and adviser at the Benioff Ocean Science Laboratory at the University of California, Santa Barbara, asserts that the rush to begin mining should slow down while more science is gathered. She says: "More countries must step up and say they will not approve deep-sea mining unless and until there is sufficient scientific research on the potential risks and strong regulations can be put in place to protect these hidden but vitally needed ecosystems.” (Amon, 2023)

This notion was echoed by Professor Jane Lubchenco, former administrator of the U.S. National Oceanic and Atmospheric Administration and current Deputy Director for Climate and Environment under the Biden Administration, who succinctly stated that it is “time to press pause [on seabed mining].” (Doyle, 2019)
**Recommendations**

Mining in the biologically rich and poorly known areas of the deep sea would knowingly put important ecosystems at risk, thereby contravening international obligations to ensure the protection of the marine environment. Deep-sea mining raises widespread concerns about habitat and ecosystem vulnerability, climate impacts, and regulatory deficiencies. Given the lack of independent scientific information required for a thorough environmental impact assessment, a moratorium is crucial.

Diverse, dense coral community, Debussy Seamount. Several colonies were very large, indicating a stable environment for many years.© NOAA

**References**


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**About the DSCC**

The Deep Sea Conservation Coalition (DSCC) was founded in 2004 to address the need to prevent damage to deep-sea ecosystems and the depletion of deep-sea species on the high seas from bottom trawling and other forms of deep-sea fishing. The DSCC is made up of over 100 non-governmental organizations (NGOs), fishers organizations and law and policy institutes, all committed to protecting the deep sea.

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