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Five reasons to take the precautionary approach to deep sea exploitation

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Extractive activities in the deep sea are poised to advance faster than the science needed to evaluate risks. Here, we call for a strong precautionary approach in developing these industries.

Food and energy insecurity have been exacerbated by climate change, conflict, and disease, with global energy demands only expected to grow. Seabed mining and deep-sea fishing have been suggested as ways to support shifting to renewable energy and increasing food supply. These industries are likely to impact one of the largest habitats on Earth, our ocean's mesopelagic zone, at depths between ~200 and 1000 m. Once assumed to be lifeless, we now know the mesopelagic zone is rich with life and a vital component of the global ecosystem. Recently, industries have begun exploratory extractive activities, while our scientific understanding of the impacts of these activities on the mesopelagic zone is trailing behind (Fig. 1). Here, we outline five reasons why we advocate for a precautionary approach to deep-sea exploitation in order to make evidence-based decisions.

The mesopelagic zone is one of the largest habitats on Earth

The mesopelagic zone is estimated to host 1.8–16 billion metric tons of fish biomass[1], which is roughly 50 to 90% of the total mass of fish on Earth[2]. It is home to a rich biodiversity of fish, including bristlemouth fish and lanternfish[3], and other deep-sea organisms, such as krill and other crustaceans, squid and other cephalopods, and gelatinous organisms including jellyfish. How fishing and deep seabed mining might impact biodiversity and wider food webs is unknown and the effects should be closely monitored alongside any exploratory mesopelagic fishing or deep seabed mining activities.

The mesopelagic zone is closely connected to the ocean above and below

The mesopelagic zone is crucial for climate regulation, and for supporting commercially and ecologically important species. The oceans absorb about a quarter of our carbon dioxide emissions[4], and for carbon to be stored on climate-relevant time scales, it must pass through the mesopelagic zone to the deep sea. Many mesopelagic animals play an important role in shuttling carbon from surface waters to the deep during their daily vertical migrations: feeding in the surface ocean at night and excreting carbon at depth during the day[5]. The biodiversity of the mesopelagic zone also supports important fisheries species that rely on mesopelagic fishes for prey[6,7]. To proceed on a large scale, we first need to better understand how fishing and mining may disrupt mesopelagic food webs and impact ocean carbon uptake and related fisheries.

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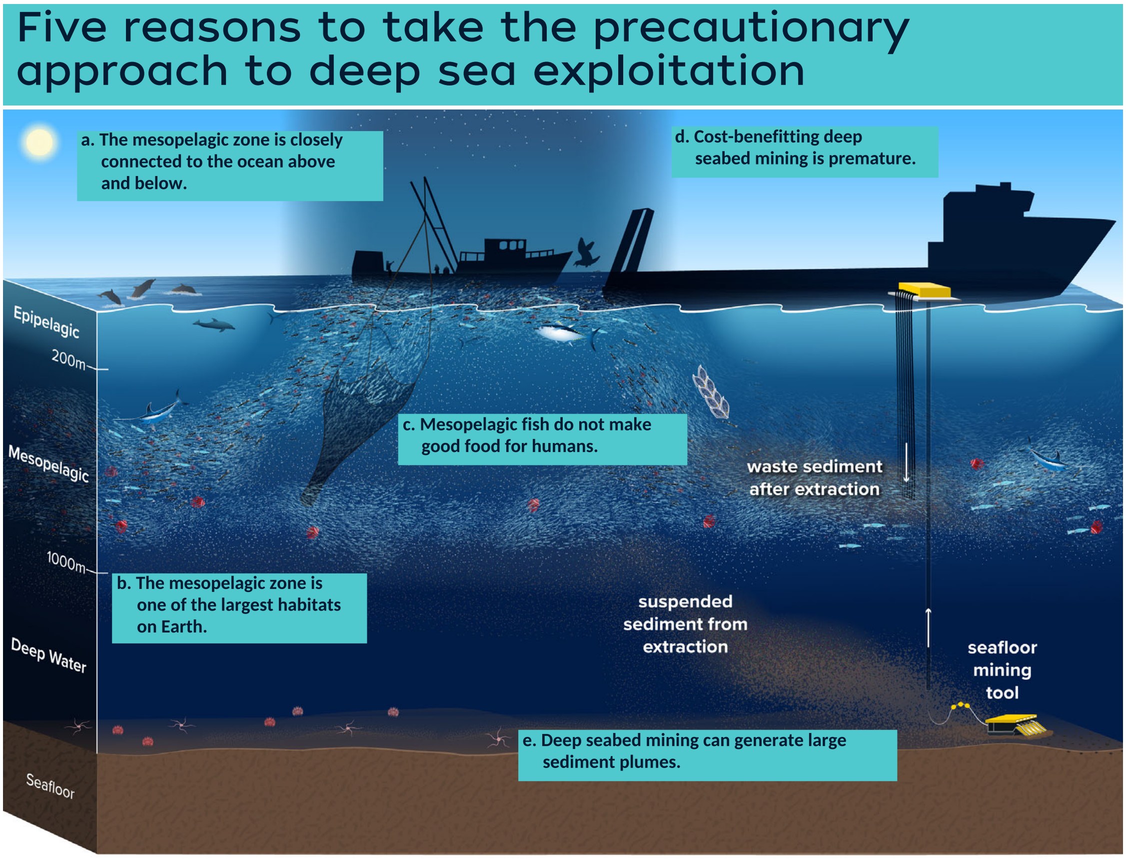

Fig. 1 Illustration of the proposed extractive activities and the response to proceed with caution. a Mesopelagic animals are essential prey for seabirds, commercial fish, and marine mammals, and their daily vertical migrations affect carbon cycling. **b** Mesopelagic ecosystems are understudied compared to the surface ocean, but we know that they contain high fish and invertebrate biomass and high biodiversity. **c** Mesopelagic fishes are generally not suitable for direct consumption, and knowledge gaps could create management challenges for sustainable fishing. **d** Environmental impacts of seabed mining are not known well enough for informed cost-benefit analyses. It is not yet clear that mining seabed metals is essential to transition to renewable energy. **e** Fine sediment that is kicked up during mining or discarded during processing could negatively impact organisms (e.g., their respiratory systems) and may introduce toxins into food webs.

Mesopelagic fish do not make good food for humans

Many mesopelagic fishes are not suitable for direct human consumption as they contain high proportions of indigestible fats[8]. Moreover, although mesopelagic fish have high global biomass, their densities in a given location can be low, requiring extraction on a significant scale to be economically feasible[9]. Evidence suggests that mesopelagic fishing has high bycatch due to the biodiversity within this habitat (i.e., the capture of non-target species, such as jellyfish, krill and other fishes)[10], which has unknown impacts on ocean food webs. While mesopelagic fishes are nutrient dense and could provide protein and fat for fishmeal for farmed fish[11], the indigestible compounds would still need to be removed and so processing costs could remain high[10]. Therefore, rigorous assessment of the ecosystem impacts of harvesting mesopelagic fishes should precede large-scale fishing activities.

Deep seabed mining can generate large sediment plumes

Mining can redistribute sediments tens or hundreds of miles via suspension and return of wastewater following ore removal. A single mining site can discharge 1.7 million cubic feet of sediment per day[12], equivalent to 1 Empire State building filled with mineral dust every 3 weeks. Once suspended, bigger (denser) sediment particles may sink and settle on the seafloor, but fine-sized sediment may remain suspended. Such sediment plumes can clog the respiratory systems of animals[13] and toxic substances may be liberated from the seafloor[14]. Improving our understanding of the ecological consequences of mining plumes on mesopelagic organisms is crucial for understanding the wider implications on this vast ecosystem[15].

Cost-benefitting deep seabed mining is premature

Conducting full cost-benefit analyses of the environmental impacts of deep-sea mining of metals is currently not possible. Compared to terrestrial mining, there is far less information on mesopelagic species distributions and ecosystem functions available for environmental impact assessments. For example, in areas where exploration seabed mining licences have been granted, less than 2% of scientific categories for environmental impact assessments have sufficient knowledge for evidence-based decision making[15]. Until such impacts can be better constrained, other solutions to support a renewable energy transition, such as enhanced metal recycling[16,17], may be preferable to deep-sea exploitation, which poses largely unknown environmental risks[15,18].

Summary

While the mesopelagic zone and deep seabed may offer us valuable resources in the future, developing safeguard policies and management strategies that adapt as science advances is critical to support responsible exploitation.

Precautionary, international efforts can help align management of ocean exploitation with the UN Decade of Ocean Science for Sustainable Development and the UN Decade on Ecosystem Restoration (2021-2030) in the long-term and at global scales. In the U.S., there is a precedent for a precautionary fishing moratorium for mesopelagic fishes to safeguard their role in the ecosystem (Pacific Fishery Management Council, 2013). Currently, there is no global policy that specifically governs mesopelagic zone extraction. Until such policies are created, science is a primary avenue by which the public and lawmakers understand and value deep sea ecosystems[19]. Already within the last few years, scientific knowledge of the mesopelagic zone has increased rapidly, with new insights into the amount of carbon dioxide being stored, revised biomass estimates of mesopelagic fish, and new economic links between mesopelagic ecosystems and society[1,19–21].

Future food and energy security solutions must align with environmental sustainability, social consciousness and equity. Thus, responsible and evidence-based governance and management of deep-sea exploitation is imperative as the consequences of mismanagement could have global consequences.

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Competing interests

The authors declare no competing interests.

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