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Shallow-water mining undermines global sustainability goals

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Coastal mineral resources are promoted as a sustainable option to meet increasing metal demands. However, shallow-water mining contradicts international conservation and sustainability goals and its regulative legislation is still being developed. In the absence of thorough comparisons of different mining practices, there are no justifications in favour of shallow-water mining.

Continental shelves as a source of critical metals

The functioning of our modern society relies on metals used by the technology, infrastructure, and energy sectors. The scarcity of land-based ores and the transition to low-carbon technologies call for new solutions to the increasing mineral demand [1]. Seabed mining (Box 1) is often framed as a more sustainable alternative to traditional terrestrial mining, with hopes for lower environmental damage and societal costs [2]. Furthermore, some seabed deposits hold higher concentrations of valuable metals compared with land-based ores, which contributes to their appeal for mining operations [3].

Most commercial seabed mining plans target metal-rich deposits from the deep seabed (below 200 m and up to ~5 km deep). While the economic potential of deep-sea minerals has been recognised for decades [4], the implementation of deep-sea mining has been held back due to concerns over the environmental impacts of mining activities on largely unknown deep-sea ecosystems, potential socioeconomic conflicts, incomplete governance frameworks, and high operational costs in offshore areas [5,6]. In light of these challenges and the resulting calls for a moratorium on deep-sea mining [5], the geological resources of the nearshore continental shelves around the world (Figure 1) have been suggested to be a comparatively low-risk option to satisfy our metal and mineral demands [7]. Shallow-water seabed mining targets high-value commodities (including metal-rich minerals) on the continental shelf in water depths up to 200 m, sometimes extending deeper. However, the expansion of shallow-water mining as a means to meet the demand for minerals has not been critically evaluated, despite it being even more imminent than deep-sea mining given the already existing technology.

Recent developments in shallow-water mining

Sand and other **aggregates** (see Glossary) have been extracted from coastal areas for decades to be used in construction and the improved methods to exploit these resources have led to several shallow-water mining initiatives in the past decades [8]. One of the most iconic examples of shallow-water mining is the offshore diamond mining initiated in Namibia in 2002, in water depths up to 130 m. Comparable **placer deposits** are also dredged off the coast of Indonesia to 70 m depth, where dredging of tin placers is the largest marine metal mining operation in the world. In New Zealand, extraction of iron-rich sand has been proposed from 20–70 m, and in Mexico mining marine **phosphorites** has been proposed in water depths of 50–100 m. While both initiatives have raised considerable environmental concerns, the iron-sand mining permit in New Zealand was rejected, yet the phosphorite mining interests in Mexico continue to seek approval from the environmental authorities. The most recent addition to large-scale shallow-water mining comes from the northern Baltic Sea. In November 2021, a Swedish seabed mining company applied for a research permit to explore the seabed in the Bothnian Sea. If approved, the aim of the exploration is to test-mine **polymetallic nodules** and eventually to commercially exploit them at depths of 60–150 m. Similar iron-manganese deposits have previously been extracted in an exploratory setting in 2007 by a Russian mining company in the eastern parts of the Baltic Sea.

As shallow-water mining has not been previously considered in many areas, its environmental regulation is inadequately reflected in national legislations. This regulatory grey area may be seen as an opportunity to circumvent stringent rules, or as a bottleneck to potential mining operations, depending on the existing regulation in place in each region. Despite regulatory uncertainties, concerns about environmental impacts, and strong civil resistance towards coastal mining operations [9], the regulatory and technical complexity of operating in deep international waters is likely to encourage further initiatives for shallow-water mining.

Glossary

Aggregates: naturally occurring coarse- to medium-grained particulate material, including sand and gravel. These nonmetallic deposits have been formed by sedimentary or hydrodynamic processes and are widely used in construction.
Phosphorites: precipitates of phosphate in shallow marine environments formed onto phosphate-rich crusts and nodules, used for fertiliser and industrial chemicals.
Placer deposits: accumulations of valuable minerals formed by surface weathering and ocean, river, or wind action during sedimentary processes. Gold, silver, tin, and platinum are examples of valuable minerals found in these deposits.
Polymetallic nodules: mineral deposits formed of precipitated iron oxyhydroxides and manganese oxides, with associated metals such as nickel, cobalt, copper, titanium, and rare earth elements. Also called manganese nodules, or concretions in shallow-water areas.

Box 1. Seabed mining

The term 'seabed mining' refers to the extraction of high-value commodities, such as metals or gemstones, from the seabed. The term is used for both deep-sea and shallow-water mining activities and thus encompasses a range of activities under different environmental and regulatory contexts. Shallow-water mining is not strictly defined by depth, but rather, shallow-water operations are usually considered to be those occurring on the continental shelf with easier access to the coast, as opposed to deep-sea operations that target less accessible resources and require specialised technology.

Despite active discussions about the use of deep-sea minerals, seabed mining is a relatively small industry and only a fraction of the known seabed mineral deposits on continental shelves are exploited currently. The main types of shallow-water minerals include: (i) mineral rich sands; (ii) polymetallic nodules and phosphorites; and (iii) placer deposits, consisting of metallic minerals or gemstones, such as tin, gold, or diamonds. While sand and gravel are the most mined materials in the world, their extraction is often considered a separate industry.

Environmental risks of shallow-water mining

Compared with terrestrial mining and costly deep-sea mining operations, shallow-water mining may save operational costs, as mining takes place closer to shore and uses existing technology. Dredging shallow seafloor minerals is efficient, with dredge rates for raw sediment material from the seabed up to 2500 m^3 per hour. While these aspects render shallow resources attractive from an economic standpoint, mining shallow-water resources does not come without risks. Mineral extraction removes the sediment, resident seafloor organisms, and ultimately the habitat, potentially resulting in local extinctions and changes in species composition. In addition to altering seabed morphology, mineral extraction results in degradation of water quality through sediment plumes that increase water turbidity and smother organisms. There is also potential release of harmful substances from the sediment and disturbance to marine organisms via noise, light, and vibration from the operations [10].

Although coastal seas are generally better studied than the deep sea, the specific impacts of shallow-water mining have been overlooked. While many impacts can be inferred from parallel industries, such as dredging, the long-term environmental

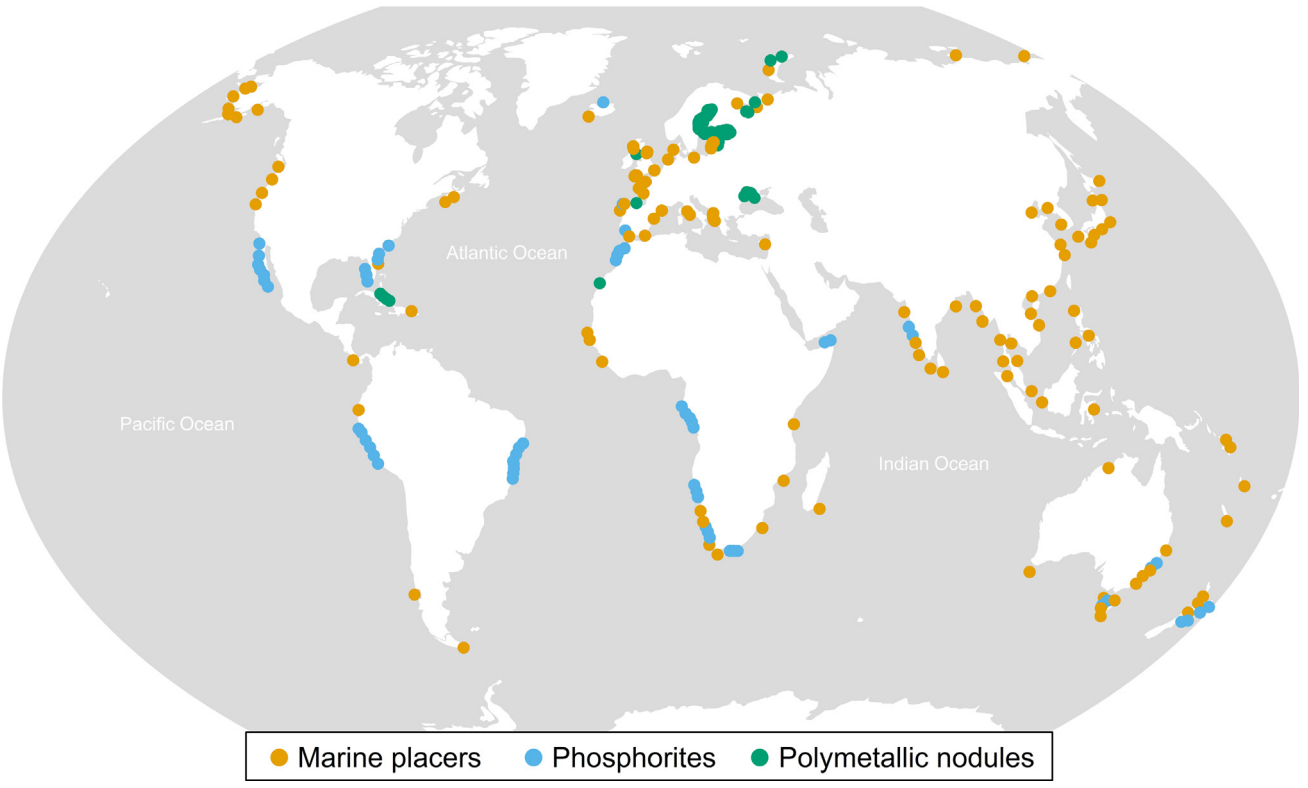


Figure 1. Overview of the currently known main marine mineral resources (marine placers, phosphorites, and polymetallic nodules) on the continental shelf, which have extraction potential defined by their proximity to coast and the depth of the resource. Data from [4], EMODnet Marine Minerals (https://www.emodnet-geology.eu/data-products/marine-minerals/), and MINDeSea (https://geoera.eu/projects/mindesea2/).

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consequences are still uncertain. Key knowledge gaps include lack of information on the spatial footprint of potential mining activities and their impacts on ecosystem functions and services. Shallow-water mining exerts additional pressures on vulnerable coastal ecosystems which are already burdened with cumulative impacts from human activities and the effects of climate change, making them less resilient to new human activities. Despite faster recovery times of shallow-water ecosystems compared with vulnerable and slow-growing deep-sea communities, the overall environmental footprint of mining will be significant also in shallow areas.

Mismatch with sustainability targets

Plans to increase seabed mining in coastal areas conflict with international conservation and sustainability objectives, which have updated targets to prevent biodiversity loss. The post-2020 Global Biodiversity Framework, introduced by the Convention on Biological Diversity, aims to protect 30% of the planet by 2030, and legislative frameworks, such as Maritime Spatial Planning (e.g., Directive 2014/89/EU) and the EU Marine Strategy Framework Directive (Directive 2008/56/EC), are in place to guide sustainable use of marine ecosystems. The UN global Sustainable Development Goals have aspirational targets to conserve and sustainably use the oceans (https://sdgs.un.org/goals), and the UN Convention on the Law of the Sea (e.g., Article 145) calls for protection of the marine environment from harmful maritime activities, including those resulting from extractive industries. Guidance has further been developed for the private sector for 'Sustainable Blue Economy' (https://www.unepfi.org/blue-finance/), where seabed mining is deemed an unsustainable and financially high-risk option to meet increasing metal demand. These agreements are in stark contrast with recent developments of exploiting seabed resources, with inevitable biodiversity loss and irreversible effects on ecosystem integrity.

Despite representing only a fraction of the global ocean, continental shelves support high species diversity, habitat heterogeneity, and biological productivity [11]. Shallow-water seabed mining likely results in cascading impacts on the ecosystem both on the seafloor and water column, with ecosystem recovery varying from years to decades [12]. This highlights the importance of a moratorium on any new type of shallow-water mining operations until the environmental and socioeconomic risks are thoroughly evaluated and when less damaging mining technology will be in place [7]. If allowed to proceed prematurely, there will be reduced options for reversing the development [13].

Conflicting narratives in support of shallow-water mining

One of the main arguments in favour of deep-sea mining in remote offshore areas has been hopes of minimal impacts on human societies [2]. In near-shore areas, mining activities are likely to overlap with other maritime sectors, such as fisheries. This results in higher likelihood of conflict over resource access and spatial claims. Mining operations can further have negative impacts on local people, either by direct disturbance from the operations and the required infrastructure on land, or via the degradation of the environment and subsequent impacts on ecosystem services [14]. Therefore, the very same reason used to legitimise deep-sea mining, assumptions of minimal disturbance to people, does not hold true for shallow-water mining. Furthermore, claims of reduced environmental impacts of shallow-water mining are not backed by credible evaluations, but by hopes and assumptions that support a pro-mining narrative. Thus far there are only few comparisons of the impacts of land-based and seabed mining, with little work done independently without support from the seabed mining industry [15]. In the absence of impartial comparisons of the ecological effects of different types of mining practices, there are no environmental or socioeconomic justifications in favour of shallow-water mining.

Shallow-water mining is not a low-risk option to meet mineral demand

In light of international commitments to halt biodiversity loss and to comply with the Sustainable Development Goals, countries should apply similar precautions to shallow-water mining as is being advocated for deep-sea mining. Even if technology would allow it, unrestricted expansion of maritime activities does not align with sustainable use of ocean resources [13]. Considering the absence of environmental regulation and risks to marine biodiversity, shallow-water mining is not a low-risk solution to overcome the environmental and ethical issues of mining on land and in the deep sea. Amidst the global transition to a low-carbon economy, precautionary conservation measures and systematic comparisons of alternative ways to obtain the required minerals must be taken before seabed mining, be it in the shallow water or in the deep sea, is allowed to proceed.

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Declaration of interests

Any views presented in this commentary are those of the authors and do not represent the official views of their affiliated organisations.

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