OCEANS

Managing mining of the deep seabed

Contracts are being granted, but protections are lagging

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POLICY

Interest in mining the deep seabed is not new; however, recent technological advances and increasing global demand for metals and rare-earth elements may make it economically viable in the near future (*1*). Since 2001, the International Seabed Authority (ISA) has granted 26 contracts (18 in the last 4 years) to explore for minerals on the deep seabed, encompassing ~1 million km² in the Pacific, Atlantic, and Indian Oceans in areas beyond national jurisdiction (*2*). However, as fragile habitat structures and extremely slow recovery rates leave diverse deep-sea communities vulnerable to physical disturbances such as those caused by mining (*3*), the current regulatory framework could be improved. We offer recommendations to support the application of a precautionary approach when the ISA meets later this July.

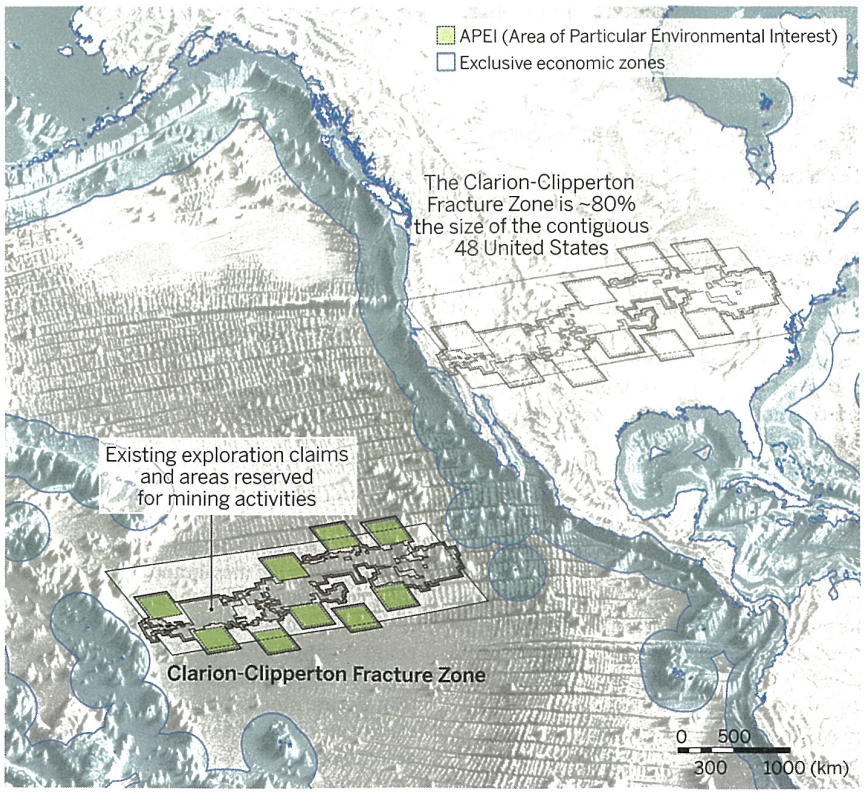
Deep-sea benthic ecosystems are globally important reservoirs of biodiversity and endemism that provide important ecosystem services (e.g., carbon sequestration and nutrient cycling) (*4*, *5*) and include diverse habitats (e.g., soft-sediment abyssal plains, hydrothermal vents, seamounts, continental slopes, and submarine canyons) (*6*). The deep seabed also harbors substantial, untapped mineral resources (e.g., polymetallic nodules containing nickel, copper, cobalt, and lithium; massive sulfides containing copper and gold; and seamount crusts containing cobalt, manganese, and rare-earth minerals) (*1*, *7*). The challenge ahead is to find ways to permit initial exploration, and ultimately commercial exploitation, of seabed minerals while sustaining the ecosystems that surround them.

The seabed outside of national jurisdictions [called the "Area" in the United Nations Convention on the Law of the Sea (UNCLOS)] is legally part of the "common heritage of mankind" and is not subject to direct claims by sovereign states (*8*). The common-heritage principle imposes a kind of trusteeship obligation on the ISA, created under UNCLOS in 1994, and its member states, wherein "the interests of future generations have to be respected in making use of the international commons"; those interests include both resource exploitation and environmental protection (*9*).

At its July 2015 session, the ISA, for the first time, will consider a draft regulatory framework to manage exploitation of these seabed resources consistent with the common heritage principle. In addition, the current regulatory framework for seabed mineral exploration could be improved. The ISA could develop a process to establish regional environmental management plans as part of the framework for governing both exploration and exploitation of deep seabed minerals, that includes a network of no-mining areas among other measures to protect the marine environment.

PIONEERING PRECAUTION IN THE ABYSSAL PACIFIC. Efforts focused on the Clarion-Clipperton Fracture Zone (CCZ) in the abyssal Pacific provide a useful model (see the map). The CCZ has the largest known concentrations of high-grade polymetallic nodules, with potentially great commercial value (*7*). The scale of impacts that would be associated with nodule mining in the CCZ may affect 100s to 1000s of km² per mining operation per year (*3*). In 2007, an international workshop brought together expert representatives from ISA and the scientific and international ocean law communities to develop design principles and recommendations for a network of marine protected areas (MPAs) in the CCZ off-limits to mining, to be considered by the ISA as part of a regional environmental management plan. The workshop used a recent assessment of biodiversity, species ranges, and gene flow in the CCZ to develop recommendations honoring existing mining exploration claims while incorporating accepted principles of ecosystem management (see the map).

MPA networks support a precautionary approach for managing ecosystems where



Region targeted for nodule mining in the abyssal Pacific. The vast extent of mining exploration claims and areas reserved for mining in the CCZ in the abyssal Pacific Ocean.

data are limited (e.g., in the deep sea) by preserving replicated portions of diverse habitats and associated biodiversity and ecosystem function (*10*), in situations where exploitation may cause serious, unpredictable, and potentially irreversible damage. The efficacy of individual MPAs to protect biodiversity and critical habitats has been well documented in the marine environment, and MPA networks further safeguard against uncertainty and promote ecosystem connectivity in the face of environmental degradation. Recent studies have demonstrated that the effectiveness of MPA networks is greater than the sum of the effects of individual MPAs (*11*).

In 2012, the ISA pioneered a precautionary approach in the CCZ when it provisionally adopted the deep seabed's first environmental management plan that included Areas of Particular Environmental Interest (APEIs), a modified version of the recommended MPA network from the 2007 workshop (*12*, *13*). The design principles used in developing the APEIs included (i) compatibility with the existing legal framework of the ISA for managing seabed mining and protecting the marine environment. (ii) minimizing socioeconomic impacts by honoring existing exploration claims; (iii) maintaining sustainable, intact, and healthy marine populations; (iv) accounting for regional ecological gradients; (v) protecting a full range of habitat types; (vi) creating buffer zones to protect against external anthropogenic threats (e.g., mining plumes); and (vii) establishing straight-line boundaries to facilitate rapid recognition and compliance (*12*).

The regional environmental management plan designated no-mining areas (i.e., APEIs) that are provisionally in place only for the CCZ (and only for 3 years, subject to review at the July 2015 ISA session) (*14*). Meanwhile, the ISA continues to grant exploration contracts for large areas of other deep-sea habitats in the Indian, Atlantic, and Pacific Oceans.

THE COMMON HERITAGE OF MANKIND. At the upcoming July session, the ISA can continue to apply a precautionary approach by tailoring the MPA network design principles established for the CCZ to other deep-sea habitats in which exploration claims will be granted. Networks of MPAs will be most effective if their location and spatial extent are established before additional mining exploration claims are granted that may compromise ISA's ability to site these networks in the most effective locations. This lesson was learned in the CCZ planning process, because existing and emerging exploration contracts required substantial modifications to the spatial location of the science-based recommendations for the proposed MPA network. Preexisting or new exploration claims (up to ~75,000 km^2 for nodules) can erode the effectiveness of protected-area networks by preempting protection of critical habitats and by limiting population connectivity by causing excessive spacing between MPAs. We thus recommend that the ISA consider suspending further approval of exploration contracts (and not approve exploitation contracts) until MPA networks are designed and implemented for each targeted region.

The ISA has the power and the opportunity to use the CCZ network design principles when it develops the regulatory framework for mineral exploitation in deep seabed areas beyond national jurisdiction. The scientific information applied in the CCZ was characteristic of this abyssal plain region, and yet the CCZ plan development process may serve as a general model for the ISA. First, the ISA could convene workshops, where scientific experts use the CCZ and other MPA design principles to develop tailored plans for MPA networks in other deep-sea regions targeted for mining (e.g., the Mid-Atlantic Ridge, Indian Ocean, and Western Pacific). Second, the ISA could then organize meetings of all stakeholders to recommend necessary revisions to the draft plans developed by the science workshops, balancing trade-offs between mining interests and environmental protection. Third, the ISA could then embed these newly tailored MPA network designs into environmental management plans for the other regions of the deep seabed targeted for mining.

"The science of establishing MPA networks and minimizing human impacts is relatively new for deep-sea mining."

The science of establishing MPA networks and minimizing human impacts is relatively new for deep-sea mining. However, given the uncertainty in the spatial and temporal scales and the intensity of mining impacts, combined with high biodiversity and extremely slow recovery rates of many communities and habitats in the deep sea, a precautionary approach using MPAs is warranted. As deep-sea protected areas are implemented, research will be necessary to evaluate their efficacy and to adaptively manage these networks as new science emerges regarding the intensity and scale of mining disturbance.

The ISA has a unique mandate to act on behalf of humankind to manage mining of deep-sea resources in the area beyond national jurisdiction. The ISA is thus responsible for applying the precautionary principle in providing appropriate and timely environmental protection of deep-sea ecosystems in regions potentially affected by mining (*15*). A carefully designed regulatory framework, including provisions for MPA networks embedded in regional environmental management plans, can reduce uncertainty about future mining activities and protect existing mining claims and economic investments, all while safeguarding deep-sea biodiversity and ecosystem function at relevant geographic scales. Although this endeavor will be challenging, the time is now to assure appropriate environmental protection in the context of mineral resource development in the deep sea. ■

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