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TITLE: Incorporating ecosystem services into environmental management of deep-seabed mining

AUTHOR: ['Jennifer Le', 'Lisa A. Levin', 'Richard T. Carson']

ABSTRACT:

Accelerated exploration of minerals in the deep sea over the past decade has raised the likelihood that commercial mining of the deep seabed will commence in the near future. Environmental concerns create a growing urgency for development of environmental regulations under commercial exploitation. Here, we consider an ecosystem services approach to the environmental policy and management of deep-sea mineral resources. Ecosystem services link the environment and human well-being, and can help improve sustainability and stewardship of the deep sea by providing a quantitative basis for decision-making. This paper briefly reviews ecosystem services provided by habitats targeted for deep-seabed mining (hydrothermal vents, seamounts, nodule provinces, and phosphate-rich margins), and presents practical steps to incorporate ecosystem services into deep-seabed mining regulation. The linkages and translation between ecosystem structure, ecological function (including supporting services), and ecosystem services are highlighted as generating human benefits. We consider criteria for identifying which ecosystem services are vulnerable to potential mining impacts, the role of ecological functions in providing ecosystem services, development of ecosystem service indicators, valuation of ecosystem services, and implementation of ecosystem services concepts. The first three steps put ecosystem services into a deep-seabed mining context; the last two steps help to incorporate ecosystem services into a management and decision-making framework. Phases of environmental planning discussed in the context of ecosystem services include conducting strategic environmental assessments, collecting baseline data, monitoring, establishing marine protected areas, assessing cumulative impacts, identifying thresholds and triggers, and creating an environmental damage compensation regime. We also identify knowledge gaps that need to be addressed in order to operationalize ecosystem services concepts in deep-seabed mining regulation and propose potential tools to fill them.

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