



# A procedural framework for robust environmental management of deep-sea mining projects using a conceptual model

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## ABSTRACT

Robust environmental management of deep-sea mining projects must be integrated into the planning and execution of mining operations, and developed concurrently. It should follow a framework indicating the environmental management-related activities necessary at each project phase, and their interrelationships. An environmental management framework with this purpose is presented in this paper; it facilitates the development of environmental information and decision-making throughout the phases of a mining project. It is based on environmental management frameworks used in allied industries, but adjusted for unique characteristics of deep-sea mining. It defines the gathering and synthesis of information and its use in decision-making, and employs a conceptual model as a growing repository of claim-specific information. The environmental management activities at each phase have been designed to enable the implementation of the precautionary approach in decision making, while facilitating review of adaptive management measures to improve environmental management as the quantity and quality of data increases and technologies are honed. This framework will ensure fairness and uniformity in the application of environmental standards, assist the regulator in its requirements to protect the environment, and benefit contractors and financiers by reducing uncertainty in the process.

## 1. Introduction

Although there is currently no exploitation of deep-sea mining minerals in international waters, action by this emergent industry appears impending. The International Seabed Authority (ISA), which has regulatory authority for the seabed and its mineral resources in areas beyond national jurisdiction, has awarded 28 exploration contracts for polymetallic nodules, seabed massive sulphides and cobalt-rich ferromanganese crusts by public and private entities (hereafter 'contractors'; 1). In addition, plans for mining in areas under national jurisdiction are also being implemented, with mining licenses awarded for seabed massive sulphides in Papua New Guinea and metal-rich sediments of the Red Sea. Of these, mining at the Solwara-1 site off Papua New Guinea [2] may be the first test case, both in terms of economic and

environmental outcomes. Terrestrial mining has not had a good environmental track record, and the social acceptance of other offshore industry activities has decreased following recent disasters (e.g. Deepwater Horizon; 3). Expectations for environmental protection associated with a 'social license' for exploitation influence the regulatory and political processes governing operations [4], and are an important factor for the offshore oil and gas industry. Thus, the success of the deep-sea mining (DSM) industry depends, in part, on securing and maintaining a social license to operate through effective environmental management [5].

The ISA is legally required to adopt the necessary measures to ensure effective protection of the marine environment from harmful effects that may arise from DSM activities [6, Article 145; 7]. Furthermore, the ISA is tasked with the regulation, coordination, and the

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management of multiple mining activities in space and time, accounting for the impacts of one activity on another [8], and any cumulative impacts, over the region and long timescales. A holistic approach that considers the whole ecosystem, including each project and the strategic environmental management of the region, is necessary to achieve these aims [9]. At a regional scale, an Environmental Management Plan for polymetallic nodule mining in the Clarion-Clipperton Zone was developed [10,11], which established mining-free areas outside the existing exploration claims. The Legal and Technical Commission (LTC) of the ISA, which is tasked with drafting the environmental rules, regulations and procedures for adoption by the ISA Council, recommended the plan following advice from experts [12], and it was adopted by the ISA Council in 2012 [11]. Whether the plan is binding on contractors, in particular those with exploration contracts predating the decision, is somewhat unclear [13]. Furthermore, while spatial management has been considered in this plan, it does not include temporal considerations.

At the level of individual mining claims, the ISA has gradually developed regulations for contractors as needed with each new phase of mining. As such, the ISA has adopted regulations for prospecting and exploration [14–16], and is currently developing regulations for exploitation activities. This has occurred without the context of transparent environmental strategies, at global, regional or project scales [17]. Existing recommendations to guide contractors in undertaking environmental impact assessments [18] relate primarily to baseline studies and environmental data collection during the exploration phase, but do not yet indicate how this information is to be linked for test mining, exploitation, monitoring or other future activities within a project, or for regional assessments.

Robust ecosystem assessment should include the ‘formal synthesis and quantitative analysis of information on relevant natural and socioeconomic factors, in relation to specified ecosystem management objectives’ [19], and should be updated during the project as more information becomes available, increasing the knowledge base and improving management approaches. Thus, environmental management at the project scale must be integrated into the planning and execution of mining operations, and developed concurrently. To facilitate this process, environmental management activities should follow a framework that considers linkages between project phases, and their interrelationships. Such a framework has been recommended by the International Marine Minerals Society [20] as a voluntary measure, by industry [21], alluded to by the World Bank as important to financing [22], and may also be included in a Mining Code [10]. However, such a framework has not yet been developed.

As several exploration contracts have recently expired and subsequently entered their first extension period, and draft exploitation regulations are being developed, guidance for a holistic environmental management framework is a timely task. Ideally, such a framework would be introduced before exploitation contracts and further exploration contracts are granted, as it would be difficult to implement environmental controls and ensure fairness between contractors after exploitation begins [13]. Similar concerns regarding timing apply to the establishment of protected areas [12,23]. Industry has also acknowledged that the presence of guidance governs their action; concerns over legal risks of operating in the international seabed ‘Area’ related to the lack of defined regulations has resulted in increased focus on prospecting in EEZs [24].

The adoption of a project-scale environmental management framework (EMF) by the ISA and national regulators for DSM would have four main benefits:

1. An EMF would promote the timely development and adoption of appropriate environmental management measures in parallel and integrated with project decision-making.
2. Technical aspects of the process would assist the ISA in operationalising its obligation to protect the marine environment from

impacts of mining, both with respect to managing impacts from an individual project, and the cumulative impacts of multiple projects. It would also be of benefit to national regulators.

3. Implementation of a standard process would benefit contractors by reducing uncertainty in planning, application, and undertaking of exploitation activities, and the collection and reporting of environmental information, while providing some certainty of process to financiers, and reducing disparity in action and reporting to the regulator.
4. An EMF would ensure fairness and uniformity in the application of environmental standards, in conformity with the principle of the common heritage of mankind [6, Article 136] and taking into account the responsibility and liability of contractors and sponsoring states.

## 2. Principles and scope of framework design

This article provides a good practice framework to guide the environmental management of DSM activities, including recommendations on regulatory oversight and review. This EMF is provided on a project-specific basis, but assumes the integration by individual projects of regional and strategic management objectives and plans. The scope is limited to the environmental management of the planning and execution of DSM exploration, extraction and rehabilitation activities, and does not include transportation, port-based, on-shore or land-based activities.

While informed by practices of other extractive industries, principles for the framework are specific to the DSM context, including environmental, socioeconomic and legal/governance factors. These principles are described in detail below, with reference to key literature:

- 1) The EMF meets the standards of the United Nations Convention on the Law of the Sea [UNCLOS; 6, articles 136, 145, 162, 165 and 192], including the principles of the common heritage of mankind, protection and preservation of the marine environment, and prevention of damage to marine flora and fauna. It builds on environmental management practices in other established related industries with similar types of activities, work in similar environments, or with similar environmental risks, and more well-developed environmental management schemes; these include terrestrial mining [25], onshore and offshore oil and gas exploration and extraction [26–29], and the shallow marine UK aggregate industry [30], but adapted for the unique conditions of DSM.
- 2) The EMF is designed to be applicable to all types of DSM in international and national jurisdictions (polymetallic nodules, seabed massive sulphides, cobalt-rich crusts, and others).
- 3) The design of the EMF considers the existing environmental management conditions imposed by the ISA [14–16], to ensure its compatibility. Any recommendations for changes to these to ensure robust environmental management are justified and highlighted.
- 4) The EMF is designed to ensure that project-based environmental management follows and facilitates the objectives and policies of the strategic and regional environmental management plans, by suggesting points in the process at which to relay information between these management documents.
- 5) The EMF is designed to facilitate integrated ecosystem assessment by ensuring that all data are formally synthesized and related to the management objectives and regulations to inform decision-making as a project progresses. Relevant data include all current and previous environmental data, up-to-date information on the project scope and plan, and the best available technology (BAT) for both mining and environmental monitoring. The EMF reflects the incremental nature of the development of the project. In facilitating formal quantitative synthesis and review at project intervals, the EMF supports ecosystem-based management, including the assessment and management of cumulative impacts, and interactions among components [as suggested by 19].

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