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VentBase: Developing a consensus among stakeholders in the deep-sea regarding environmental impact assessment for deep-sea mining—A workshop report

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ABSTRACT

Mining seafloor massive sulfides for metals is an emergent industry faced with environmental management challenges. These revolve largely around limits to our current understanding of biological variability in marine systems, a challenge common to all marine environmental management. VentBase was established as a forum where academic, commercial, governmental, and non-governmental stakeholders can develop a consensus regarding the management of exploitative activities in the deep-sea. Participants advocate a precautionary approach with the incorporation of lessons learned from coastal studies. This workshop report from VentBase encourages the standardization of sampling methodologies for deep-sea environmental impact assessment. VentBase stresses the need for the collation of spatial data and importance of datasets amenable to robust statistical analyses. VentBase supports the identification of set-asides to prevent the local extirpation of vent-endemic communities and for the post-extraction recolonization of mine sites.

Background

Seafloor Massive Sulfides (SMS) are aggregations of collapsed hydrothermal vent chimneys formed by the precipitation of metallic sulfides from hydrothermal fluids in tectonically active regions [1–3]. These SMS mounds may contain high-grade ores [4]. Recent technologic and economic factors have converged to make the possibility of mining SMS deposits a reality [5]. The absence of substantial overburden, limited infrastructural demands, and a relatively small environmental footprint makes deep-sea SMS exploitation a commercially attractive prospect, leading to a potential deep-sea gold-rush [6]. Currently, management and conservation efforts precede industrial exploitation and can provide an anticipatory, rather than reactionary, assessment of the environmental impacts of deep-sea mining.

Hydrothermal vents are biologically significant ecosystems that typically support high conservation value, endemic, communities dominated by chemoautotrophic invertebrates [7]. These communities are expected to be severely impacted by mineral extraction [8–11]]. Communities of vent endemic species are patchy and transient in nature. They can be linearly spread along oceanic ridges [12] or haphazardly arranged throughout back-arc spreading centers [13]. The ability of planktonic larvae to colonize new habitat and maintain existing populations is critical for the regional persistence of these species [14–16]. Larval supply shapes the dynamics and spatial structures of marine benthic species ecology at the population and community levels and affects the strength of post-settlement interactions, including intra- and inter-species competition, facilitation and predation, and gene flow and connectivity [17–20]. There is an urgent need to develop evidence-based criteria for the setting of conservation objectives at hydrothermal vent sites for the sustainable and responsible management of SMS resources [10,21]. There is a body of opinion arguing that our ignorance of hydrothermal-vent ecosystems is a good justification for suspending commercial exploration [22] and members of the scientific community urge caution [10]. However arguments for a complete cessation of deep-sea exploitative actions due to lack of knowledge do not stand to scrutiny when compared to routine anthropogenic activities in shallow water, for instance the exploitation of kelp forests.

Unlike SMS mining, kelp forest exploitation has a broad research base from which to draw upon ([23–25]). Despite their familiarity, our understanding of coastal ecosystems is often as limited as that for deep-sea habitats. Ref. [26] demonstrated complex patchiness in both the micro- and macroscopic constituents of kelp communities that confounded the detection of any clear response to disturbance, even when using well replicated Before After Control Impact (BACI) designed experiments (*sensu* [28,27]). In their review of kelp biotopes for the purposes of managing UK conservation sites, Birkett et al., [29] stated that “It cannot be emphasised too strongly that our present understanding of the natural fluctuations in the species assemblages, populations, distribution and diversity of species in kelp beds is very limited”. Any assessment of an anthropogenic activities' ecological risk is dependent on some appreciation of the natural variability in that system. Without an understanding of natural variability we struggle to define thresholds for environmental impacts.

The application of the globally espoused precautionary principle is often touted as a solution when the risks of the proposed exploitative process on an ecosystem are not well understood [30]. A precautionary approach suggests that a lack of scientific certainty should not preclude the adoption of cost-effective measures to control environmental risks; that exploitative activities should proceed with appropriate checks and risk reduction in place [31]: “In order to protect the environment, the precautionary

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approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation (Principle 15, [30]).” In a marine context, the International Seabed Authority (ISA) defines precaution as “caution in advance, caution practised in the context of uncertainty, or informed prudence” [32].

The precautionary principle is often vague and has conflicting definitions [33]. Neither the Rio Declaration nor the ISA Mining code define thresholds for ‘serious’ environmental damage or harm. Any defined thresholds for a ‘serious’ impact are dependent on an understanding of the natural variability in the system. However, as Myers articulates [33], “the core of each statement is the idea that action should be taken to prevent harm to the environment and human health, even if scientific evidence is inconclusive.”

VentBase guidelines

VentBase 2012, was a workshop held at the National University of Ireland, Galway, whose aim was to set standards for the data requirements of ecological assessment at SMS deposits. VentBase demonstrated both the necessity and desire among stakeholders for consensus regarding the management of SMS resources. Part of developing this consensus is establishing a common vocabulary with universal definitions and standardising methodologies to ensure results are comparable between studies. VentBase also promoted the need for the collation of datasets amenable to robust statistical analysis.

VentBase concluded that the first step in the development of coherent management approaches and practices is the collation of spatial information for describing hydrothermal-vent communities and their associated habitats. A three-stage sequence of events for the baseline survey of an SMS during the exploratory stage was proposed (see below). A suite of standardized sampling methodologies were presented to the International Seabed Authority (ISA) and recommended for inclusion in the ISA's forthcoming policies regulating the exploration and development of SMS resources in the high seas. This suite included sampling guidelines for: sample triage, video survey, hard sampling benthic fauna, plankton sampling, taxonomic protocols, sample quality assurance/control and sampling for molecular studies.

Stage one involves the definition of the physical characteristics of the site through regional mapping, including coarse bathymetric multi-beam survey, and determining prevailing current regimes. Stage two involves the definition of the biological and chemical characteristics of the site through video survey to identify ecotypes and dominant fauna within assemblages and collection of environmental data (including temperature, pH, dissolved oxygen, methane, sulfide, turbidity and redox potential). Stage three involves targeted biological sampling that adheres to InterRidge guidelines for responsible research practices at deep-sea hydrothermal vents [34]. Dominant macrofaunal assemblages are sampled for identification of taxa, establishing life-history characteristics of dominant taxa, and assessing connectivity and population structure of taxa spanning a range of life histories. All the available information from stage two of the baseline study is used for first observations to assess temporal variability.

VentBase highlighted the need for data generated from SMS EIA studies to be made available to inform future investigations through established, publicly available databases such as Dryad [35] and GenBank [36]. Resulting publications should be published Open Access to facilitate stakeholder engagement. Biological samples need to be stored securely in conditions suitable for their long-term preservation and their availability should be documented.

VentBase participants suggested that the most significant single component of a mitigation program is the establishment of appropriate ‘set-asides'. Set-asides should have similar physical, chemical and biological characteristics as the extraction site and should act as a source of recruits for recolonization of the mining area. Set-asides should be immune from the effects of mineral extraction, including impacts on fluid flow, and ideally located upstream of the extraction site. In fast spreading sites, these may be within the vent field and the proposed mining block. In slow spreading sites, they may need to be in an adjacent vent field or even outside of the proposed mining block. Concerns were raised that set-asides designated by one party may be vulnerable to disturbance from mining activities in adjacent blocks, negating the set-aside's *raison d'etre*. Without further studies, the participants were unable to comment on either recovery rates for extraction sites or release of set-aside status for mining activities. VentBase determined that if suitable set-asides cannot be identified within the ISA-permitted exploration area, a suitable set-aside site outside the permitted area should be identified.

VentBase identified significant knowledge gaps in the understanding of biological variability at SMS deposits. Management and mitigation strategies are site specific: the rate at which SMS deposits accumulate and the pace of biological succession varies across spreading centers and, for example, mitigation strategies at fast spreading centers may not be suitable at an ultraslow-spreading center. VentBase also recognized that extraction will occur potentially on hydrothermally active and inactive deposits. Biological communities associated with these disparate habitats will not share life histories, environmental tolerances, responses to disturbance, or resilience and recovery potential [21].

If deep-sea hydrothermal vent ecosystems are to be afforded the same level of management and conservation as coastal ecosystems, they must be treated as an extension of coastal ecosystems. A paradigm shift is required whereby the perceived uniqueness of individual marine ecosystems are subsumed to a generalised approach where vents are viewed as another habitat within the seascape. Only by a harmonization in approach, with methodologies as equivalently rigorous to those established for the coastal zone, can we ensure that vent ecosystems are afforded management standards mandated by the precautionary principle.

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