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Area-based management tools to protect unique hydrothermal vents from harmful effects from deep-sea mining: A review of ongoing developments

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The deep seabed in areas beyond national jurisdiction, or what is referred to as "the Area," is the common heritage of humankind, safeguarded by mandating the International Seabed Authority (ISA) to protect the marine environment and to regulate all mining-related activities on the seabed in areas beyond national jurisdiction. So far, the ISA has 7 contracts for polymetallic sulfide (PMS) exploration. PMS deposits are located at and near deep-sea hydrothermal vents, one of the most remarkable ecosystems on Earth. Where hot and mineral rich vent fluids escape from the earth's crusts, minerals precipitate and are deposited, and unique biomass rich microbial and animal communities are thriving. Several intergovernmental organizations suggest that active vents classify as areas in need of conservation. The ISA is currently developing regional environmental plans for PMS and has set some first steps to protect active vents from mining impacts. We review the current regulatory and policy framework for deep-sea spatial management, and set it into the environmental context. We conclude that all current management measures of the ISA would not be suited to protect the marine environment from harmful mining impact. We recognize that ISA's area-based management tools are under development, and suggest that improvements can be achieved by studying and recognizing the ecological attributes of ecosystems and their connectivity, as well as governance connectivity, taking into account area-based management tools of different users in the same area.

KEYWORDS

deep-sea mining, vulnerable ecosystem, international law, International Seabed Authority, area-based management tools, connectivity, science-policy interface

Introduction

The deep sea–which is the ocean below 200 meters depth and constitutes 90% of the biosphere–represents, in scientific, technological and legal terms, a new frontier for research, development and management. On the one hand, our knowledge of the deep sea remains incomplete, and unique deep-sea ecosystems are continuously being discovered (Amon et al., 2022). As described by Smith et al. "communities of inactive massive sulfides are mostly undescribed; the vast majority of seamounts in the ocean have never been sampled; the macrofauna and meiofauna of cobalt-rich crust deposits are practically unknown; and most of the [...] faunal species recently collected [...] are new to science" (Jones D. O. et al., 2020, p. 100; Smith et al., 2020, p. 856).

On the other hand, some entities have not only shown their interest in the rich minerals of the deep seabed and ocean floor beyond the limits of national jurisdiction also known as "the Area",[1] which are in high demand due to their use in the development of green and other technologies, such as mobile phones (IUCN, 2022), but have also communicated their readiness in engaging in their extraction. For example, on 25 June 2021 Nauru requested the International Seabed Authority (ISA) to adopt the rules necessary to facilitate the approval of plans of work for mineral exploitation in the deep seabed by July 2023 in light of its State-sponsored entity, Nauru Ocean Resources Inc, being ready to submit the necessary plans of work (Blanchard, 2021; Lyons, 2021; Willaert, 2021). This consequently triggered the urgency of completing the ISA's regulations for exploitation activities.

The potential imminent start of deep-sea mining poses undoubtable high risks to the marine environment with long-term negative consequences (Gollner et al., 2017). The impacts that mining could have on deep-sea ecosystems are also often misunderstood, and our ability to predict species and ecosystems' responses to stressors, as well as the behavior of sediment plumes, is limited (Van Dover et al., 2018; Smith et al., 2020, p. 855). Although all areas of mining interest are at risk, hydrothermal vents raise particular concerns considering the potential impacts of, for example, vent-fluid change, toxic mining plumes, as well as habitat removal and fragmentation, and associated risks of biodiversity loss of unique and endangered species (Van Dover et al., 2018). Mining may damage directly or indirectly the benthic environment of inactive and active vents, and the surrounding benthic and pelagic realm within and beyond a vent field, although it is uncertain to what extent (Van Dover, 2014; Gollner et al., 2021).

Similarly, many questions remain as to the (regulatory) framework[2] for the management of deep-sea hydrothermal vents and their protection from environmental harm. For example, many terms and concepts, as well as what they trigger in practice, are in need of clarification. Obligations–and who they bound–still need to be fleshed out. The interactions between the management of deep-seabed mining and that of other maritime activities is complex. Uncertainties and knowledge gaps, both in science and in law, therefore raise concerns as to our ability to ensure comprehensive environmental protection of unique deep-sea hydrothermal vents fields.

Mandated to organize, regulate and control all mineral-related activities in the international seabed (also known as "the Area") for the benefit of humankind as a whole (United Nations Convention on the Law of the Sea, 1982, art. 157(1) and 137(1)), the ISA has been developing, since the early 2000's, the Mining Code, a set of rules, regulations and procedures covering the prospecting, exploration and exploitation of minerals in the deep seabed (The Mining Code). While the ISA first developed regulations on the *exploration* of deep-sea minerals (The Mining Code: Exploration Regulations), the Secretary General now calls to aim to complete the *exploitation* regulations (Draft regulations on exploitation of mineral resources in the Area, 2019) before July 2023 (Status of the draft regulations on exploitation of mineral resources in the Area and proposed road map for 2022 and 2023, 2021).

The ISA's mandate also includes the effective protection of the marine environment from harmful effects that may arise from deep-sea mineral related activities (United Nations Convention on the Law of the Sea, 1982, art. 145). The operationalization of this environmental duty is being undertaken, among other things, through the development of area-based management tools (ABMTs). Broadly defined as tools or "approach[es] that [enable] the application of management measures to a specific area to achieve a desired policy outcome" (EU Commission UN Environment, 2018), ABMTs (also known as spatial management tools)[3] come in different shapes and sizes, with different mandates and purposes, and aim at achieving different policy goals.

Many studies have rendered detailed accounts of the international legal regime for deep-sea mining (Jaeckel et al., 2020), looking at it from the angle of marine environmental protection (Harrison, 2017), of the precautionary approach (Jaeckel, 2017), and of interdisciplinary research (Koschinsky et al., 2018), and they have presented how ABMTs are situated within that regime. The ISA itself has also published technical

1 Three different types of minerals, found in three different types of geographical/geological landscapes, are currently managed in the deep seabed/the Area: polymetallic nodules (on abyssal plains), cobalt-rich ferromanganese crusts (on seamounts), and polymetallic sulfides (on and around hydrothermal vents).

2 The authors use complementary yet different terms throughout the paper. Regulations/regulatory framework refers to legally and non-legally binding instruments that contain legal obligations and guidelines that shape, influence and direct actors' behaviors. Management refers mostly to measures and initiatives undertaken by an actor or entity with the objective to fulfill certain obligations. Policy refers to an array of laws, regulations, instruments, guidelines, strategies, procedure, etc. that guide decision-making. Finally, governance is used here as a more holistic concept, which encompasses regulations, policy, management, but also institutions and more broadly defined processes.

3 The terms ABMTs and spatial management tools are used interchangeably throughout the present paper.

studies and reports on various related topics, including on the design of some spatial management tools (ISA, 2017; Towards and ISA Environmental Management Strategy for the Area, 2017) and plans (Guidance to facilitate the development of Regional Environmental Management Plans (REMPs), 2019). Similarly, many publications from different domains of the natural sciences, such as marine biology, oceanography and ecology, have studied different elements/criteria that need to be considered when designing and establishing ABMTs for the deep sea (Dunn et al., 2018; Gollner et al., 2021).

The present paper reviews this body of knowledge and discusses the optimization of ABMTs to address, both at the operational and regulatory levels, the effective protection of the marine environment from harmful effects.

State of affairs

Definition of the marine environment

The term "marine environment" is not defined in the *United Nations Convention on the Law of the Sea* (UNCLOS) (United Nations Convention on the Law of the Sea, 1982) nor under its *Agreement relating to the Implementation of its Part XI* (Part XI Agreement) (Agreement relating to the implementation of Part XI of the United Nations Convention on the Law of the Sea of 10 December 1982, 1994). To understand the scope of this term in the context of deep-sea mining, one must therefore resort to the definition found under the *Draft Regulations on exploitation of mineral resources in the Area* (Draft Exploitation Regulations) (Draft regulations on exploitation of mineral resources in the Area, 2019), which refers to "the physical, chemical, geological and biological components, conditions and factors which interact and determine the productivity, state, condition and quality and *connectivity* of the marine ecosystem(s), *the waters of the seas and oceans* and the airspace above those waters, as well as the seabed and ocean floor and subsoil thereof" (emphasis added).

Thus, the legal definition addresses that the ocean is interconnected, from the surface to the seafloor and from the coasts to the high seas. For life in the ocean, there exists only one ocean with no sectoral or State boundaries. Ecological connectivity plays a critical role in healthy ocean functions, and describes the ecological linkages within and between locations and habitats, the individual organisms and the resources they require. The degree of knowledge on connectivity can ultimately determine the success or failure of area-based management (Ecological Connectivity: Implications for Ocean Governance, 2020).

Regulatory and policy framework for deep-sea spatial management

Different areas of the deep seabed fall under the scope of existing ABMTs. In order to assess their potential for the protection of active hydrothermal vents, this section first draws an overview of the nature and extent of existing ABMTs developed in the framework of the ISA, and then briefly discusses selected ABMTs from other sectors that can/could be of relevance for the protection of deep-seabed ecosystems from the impacts of mining.

ABMTs developed for polymetallic nodules under the ISA framework

As part of its mandate to control mineral-related activities and its obligation to ensure the effective protection of the marine environment from harmful effects that may arise from such activities, (United Nations Convention on the Law of the Sea, 1982, art. 145) the ISA has developed specific tools for spatial management. Three main tools are currently found in regulatory and policy instruments adopted by the ISA: areas of particular environmental interest (APEIs), which have a purely preservation aim, impact reference zones (IRZs) and preservation reference zones (PRZs), mostly intended for monitoring purposes.

Areas of particular environmental interest

APEIs are areas of the seabed closed to any mining activities, but open for marine scientific research (MSR) (Jaeckel, 2017, p. 202). For now, APEIs have only been established for polymetallic nodules in the Clarion-Clipperton Zone (CCZ) in the Pacific Ocean, through the REMP adopted for that region in 2012 (Environmental Management Plan for the Clarion-Clipperton Zone, 2011; Decision of the Council relating to an environmental management plan for the Clarion-Clipperton Zone, 2012). Nine APEIs were initially designated in the CCZ, each with a size of 400 x 400 km. This area includes a core-area of 200 x 200 km and a buffer zone of on each side 100 km to ensure that it is not affected by mining plumes from any activities immediately adjacent to an APEI (Environmental Management Plan for the Clarion-Clipperton Zone, 2011, para. 25; Lily and Roady, 2020, p. 340; Jones D. et al., 2020, p. 104). This size is "designed to be large enough to maintain minimum viable population sizes for species within the proposed mining areas *via* self-recruitment after mining has ceased" (Jones D. et al., 2020, p. 104). They have been geographically located based on knowledge on topography, particulate organic carbon flux (food for deep-sea animals), and nodule abundance (Review of the implementation of the Environmental Management Plan for the Clarion-Clipperton Zone–Report recommendations of the Legal Technical Commission, 2021, para. 22). As such, APEIs qualify as ABMTs aimed at the protection of representative habitats and facilitation of MSR (Jaeckel, 2017, pp. 203–204; Rayfuse, 2020, p. 541). APEIs have been characterized as embodying the application of a precautionary approach (Lodge, 2017, p. 167) because they completely close the designated areas to mining activities. APEIs, however, are meant to be reviewed and can therefore be subject to modifications or eventually become completely or partially open to mining activities (Christiansen et al., 2022, p. 8).

A three-dimensional extent of APEIs' protection can be inferred from their nature: if no mining is allowed in a specific area, then both the sea floor and the superjacent waters would technically be protected from the impacts of mining. Yet, this reasoning needs to be seen in light of three elements. First, as the geographical extent of the impacts of mining are not yet fully understood, the set 100 km buffer zones may not be fully adequate. Mining impacts could reach far beyond the directly mined area, in the form of, for example, plume dispersal (Weaver et al., 2022), or noise from deep-sea mining that may span vast ocean areas (Williams et al., 2022). The buffer zones of APEIs partly but not fully take these far-reaching impacts into account, as for example noise travels far (Williams et al., 2022). Second, the species and associated functions found inside APEIs may be different from the species and functions in the designated mining areas, and thus could not prevent for example potential species extinction. Recent studies showed that many species in the CCZ have small distribution ranges (<200 km) or limited dispersal modes (Bonifàcio et al., 2020; Brix et al., 2020). Thus, species with natural distribution ranges smaller than contractor areas may face extinction risks, as they could be killed by mining but are found no-where else (also not in APEIs). A new study shows that for example APEI6 is only partially representative of the exploration areas to the south, as there are differences in community composition of microbes and animals (Jones D. O. et al., 2020). Further, the current APEIs typically have lower nodule densities than the exploration areas, and scientific evidence shows that polymetallic nodules are needed to preserve the fauna on the nodules (Vanreusel et al., 2016) and the food-webs (Stratmann et al., 2021), as many animals are dependent on nodules and cannot live without them (Cuvelier et al., 2020). Thirdly, APEIs are sectoral tools, meaning that they only offer protection from mining activities and their impacts. The protection offered by APEIs does not extend to other deep-sea activities (e.g., bottom fishing) and their impacts; consequently, APEIs do not offer multi-sectoral protection nor protection from cumulative impacts coming from different sectors.

A heated legal debate preceded the designation of APEIs in the CCZ. First, although there was initial doubt as to the legal basis upon which APEIs could be established (Lodge et al., 2014, p. 69), it was later on found that their establishment fell under the broad powers of the ISA under articles 145, 165(2)(e) and 162 UNCLOS to restrict mining activities for environmental reasons (Jaeckel, 2017, p. 203; EU Commission UN Environment, 2018). Second, the size and location of some of the initial nine APEIs were modified from original scientific advice because exploration contracts had already been granted in some of those areas (Wedding et al., 2013; Rayfuse, 2020, p. 541). These modifications were criticized: adjusting the location of APEIs to accommodate mining activities somewhat defeats the purpose of APEIs as protected areas (Jaeckel, 2017, pp. 206–208).

The CCZ REMP underwent a review of its overall implementation progress, which was published in 2021 (Environmental Management Plan for the Clarion-Clipperton Zone, 2011, paras 42 and 45; Jaeckel, 2017, p. 208; Lily and Roady, 2020, p. 340; Review of the implementation of the Environmental Management Plan for the Clarion-Clipperton Zone–Report recommendations of the Legal Technical Commission, 2021). Despite the above-mentioned criticism, the review highlighted an overall success in terms of APEI-related objectives: all management (e.g., keep under review the APEIs and determine their suitability or need for amendment) and operational objectives (e.g., protect biodiversity and ecosystems; include a wide range of habitats; avoid overlap with the current distribution of claimant and reserved areas; and provide a degree of certainty to existing and prospective contractors by laying out the location of areas closed to mining activities) were implemented (Review of the implementation of the Environmental Management Plan for the Clarion-Clipperton Zone–Report recommendations of the Legal Technical Commission, 2021, paras 10 and 15). The review recommended the establishment of additional APEIs in the CCZ, based on "the recognition of a need for improvement in representativity, replication and connectivity, which will strengthen the effectiveness of the [APEI] network" (Review of the implementation of the Environmental Management Plan for the Clarion-Clipperton Zone–Report recommendations of the Legal Technical Commission, 2021, p. 26). Four additional APEIs, one being significantly smaller than 400 x 400 km and thus not including the 100 km buffer zone as suggested in the original design for APEIs, were approved in December 2021 (Review of the implementation of the Environmental Management Plan for the Clarion-Clipperton Zone–Report recommendations of the Legal Technical Commission, 2021).

Impact and preservation reference zones

Simply put, the main purpose of reference zones (RZs) is to facilitate monitoring (Environmental Management Plan for the Clarion-Clipperton Zone, 2011, para. 41(c); ISA, 2017, pp. 9 and 13; Jones D. O. et al., 2020) and evaluate the environmental impacts of mining activities (Hao et al., 2020, p. 2; Jones D. O. et al., 2020, p. 4). Two types of RZs exist (Jaeckel, 2017, pp. 211–214; Jones D. O. et al., 2020, p. 104; Rayfuse, 2020, p. 541; Recommendations for the guidance of contractors for the assessment of the possible environmental impacts arising from exploration for marine minerals in the Area, 2020, pp. 35–37). First, IRZs shall lie in the area that will be mined and where impacts of mining will be assessed (Jones D. O. et al., 2020).

For their part, PRZs are areas where no mining is allowed. They should be located within a contract area and extend up to a distance "where impact can no longer be detected" (Design of Impact Reference Zones Preservation Reference Zones in Deep Sea Mining Contract Areas, 2018, p. 5), as they act mostly as monitoring control sites for IRZs (Jones D. O. et al., 2020, p. 4) and for the contract areas more generally. This might explain a suggestion that has arisen to rename PRZ as "control reference zones" (DOSI, 2019). It has been suggested that PRZs should be located close enough to mining sites, to allow the disturbed mining sites to be repopulated after activities have ceased, but they need to be large and far enough from mining sites to ensure that they are not affected by indirect effects of mining such as plumes (ISA, 2017, p. 18; Jaeckel, 2017, p. 213). Both IRZs and PRZs should be geophysically and environmentally similar to the contract areas in order to be used for monitoring the impact of activities. Yet, ensuring that adjustments can be made to these zones might be necessary in order for them to also be relevant to assess the impact of sediment plumes, about which little is currently known (Jones D. O. et al., 2020, p. 5). As these zones might also be affected by other activities (e.g., fishing), their environment, and consequently their nature as "reference" zones, could be affected. All these elements illustrate that establishing the location and size of these zones remains a challenge.

A further challenge stems from the name of PRZs, which could lead to believe that they have a preservation purpose. In fact, it has been proposed by one commentator that, because of their location closer to mining sites, "PRZs could also play important roles for conservation, for example providing connectivity as 'stepping stones' and sources for recolonization for impacted sites" (Jones D. O. et al., 2020, p. 4). The ISA Secretariat has, however, reiterated that the use of the word "preservation" should not be seen as transforming PRZs–which are in essence monitoring tools–into permanent/long term tools for conservation, a role currently fulfilled by APEIs (at least in the CCZ, potentially through other tools in other regions) (ISA, 2017, pp. 11–12 and 15).

Under the Regulations on prospecting and exploration (Regulations on Prospecting Exploration for Polymetallic Nodules in the Area, 2000; Regulations on Prospecting Exploration for Polymetallic Sulphides in the Area, 2010; Regulations on Prospecting Exploration for Cobalt-rich Ferromanganese Crusts in the Area, 2012), RZs must be included by contractors in their plans of work for exploration "if required by the Council" (Regulations on Prospecting Exploration for Polymetallic Nodules in the Area, 2000, r. 31(6); Regulations on Prospecting Exploration for Polymetallic Sulphides in the Area, 2010, r. 33(6); Regulations on Prospecting Exploration for Cobalt-rich Ferromanganese Crusts in the Area, 2012, r. 33(6)). This power given to the Council probably comes from the fact that the necessity of RZs was only envisaged for exploration activities that have the potential of creating serious environmental harm, which would happen only through exploration activities that cause disturbances on the seafloor (Recommendations for the guidance of contractors for the assessment of the possible environmental impacts arising from exploration for marine minerals in the Area, 2013, para. 26(d); Jaeckel, 2017, pp. 212–213)[4]. With the recent start of test mining, disturbances to the seabed became a reality; yet, the designation of RZs remains a recommendation (c.f. binding obligation) from the Legal and Technical Commission (LTC) (Recommendations for the guidance of contractors for the assessment of the possible environmental impacts arising from exploration for marine minerals in the Area, 2020, para. 67). Contractors such as the Federal Institute for Geosciences and Natural Resources (BGR) and Global Sea Mineral Resources (GSR) have however been following these recommendations (Environmental Impact Assessments), as a contractor who does not designate RZs is very unlikely to have reference baselines and therefore be in any position to submit an environmental impact statement (EIS). The uncertainty regarding the obligation to designate RZs, including standards and guidelines on what scientific bases they should be selected, will hopefully be clarified in the Draft Exploitation Regulations, including through the addition of a regulation on test mining, currently being negotiated (Facilitator's Revised Text : Draft regulations on exploitation of mineral resources in the Area–Parts IV VI related Annexes, 2022, r. 48bis). Annexes to the Draft Exploitation Regulations already contain a requirement for contractors to include the location of RZs, although specificities remain to be clarified (Facilitator's Revised Text : Draft regulations on exploitation of mineral resources in the Area–Parts IV VI related Annexes, 2022, p. Annex IV, para 3.1.1, and Annex VII, 2(i)).

It can be assumed that the monitoring function of RZs would target all impacts of mining activities in a specific area, meaning this could also extend to the water column. Yet, it could also be logical to conclude that the complete role and extent of RZs will depend on the way in which they are designed and designated by contractors. In fact, the designation of RZ is subject to important variations "due to differences in designation practices, as different contractors have their specific plans for surveys and long-term monitoring" (Hao et al., 2020, p. 2). A technical study published by the ISA (ISA, 2017) aimed to give some guidance to contractors in that regard; yet, according to some commentators, a clear set of harmonized "methods and steps for the designation of RZs in different environmental conditions to guide each contractor is urgently required" (Hao et al., 2020, p. 2).

4 Jaeckel observes that in the original Regulations on Prospecting and Exploration for Polymetallic Nodules, RZs were only necessary in applications for exploitation. Their necessity in applications for exploration was included in the Regulations on Prospecting and Exploration for Sulfides and Ferromanganese Crusts, and subsequently in the revised version (and now current) of the Regulations on Prospecting and Exploration for Polymetallic Nodules.

Other tools

Two other types of ABMTs[5] which interact with the deep seabed and its ecosystems, although that are not related to deep-sea mining, are also of relevance for the present discussion.

The first tool, developed in the context of deep-sea fisheries, are Vulnerable Marine Ecosystems (VMEs). This concept emerged from the need, raised in Resolutions of the United Nations General Assembly (UNGA) (Sustainable fisheries, 2004, para. 67; Sustainable fisheries, 2006, pp. 80–83), to address the adverse impacts of bottom fishing, including bottom trawling, on VMEs in areas beyond national jurisdiction (ABNJ). The UNGA indeed called upon States, through the relevant regional fisheries management organizations (RFMOs), to adopt the appropriate conservation and management measures to "protect vulnerable marine ecosystems, including seamounts, hydrothermal vents and cold water corals, from destructive fishing practices, recognizing the immense importance and value of deep sea ecosystems and the biodiversity they contain," in line with the precautionary and ecosystem approaches (Sustainable fisheries, 2004, p. 67; Sustainable fisheries, 2006, p. 80).

A couple of years later, the Food and Agriculture Organization, as part of its International Guidelines for the Management of Deep-sea Fisheries in the High Seas, provided a list of characteristics to identify VMEs and assess significant adverse impacts (International Guidelines for the Management of Deep-sea Fisheries in the High Seas, 2009, para. 42)[6]. The Guidelines also elaborate on the way flag States and RFMOs should conduct the assessments to "establish if deep-sea fishing activities are likely to produce significant adverse impacts in a given area" (International Guidelines for the Management of Deep-sea Fisheries in the High Seas, 2009, para. 47), as well as ways to ensure enforcement and compliance (International Guidelines for the Management of Deep-sea Fisheries in the High Seas, 2009, paras 54 and following).

VME identifications are intended to lead to the adoption of conservation and management measures by RFMOs. For example, the North-East Atlantic Fisheries Commission (NEAFC) has adopted recommendations that include, among other measures (Recommendation 19 2014: Protection of VMEs in NEAFC Regulatory Areas, as Amended by Recommendation 09:2015 and Recommendation 10:2018, 2018, art. 3), area closures for the protection of VMEs, which also cover parts of the northern Mid-Atlantic Ridge (nMAR) (Recommendation 19 2014: Protection of VMEs in NEAFC Regulatory Areas, as Amended by Recommendation 09:2015 and Recommendation 10:2018, 2018, art. 5), as well as a strict procedure for engaging in exploratory bottom fisheries outside area closures (Recommendation 19 2014: Protection of VMEs in NEAFC Regulatory Areas, as Amended by Recommendation 09:2015 and Recommendation 10:2018, 2018, arts. 6–7). The recommendations also contain rules to abide by if fishing vessels encounter evidence of VMEs. These include the necessity to cease fishing and move away from the VME-evidenced location, as well as quantify the catch of VME indicators, which could later on be used to establish a temporary closure (Recommendation 19 2014: Protection of VMEs in NEAFC Regulatory Areas, as Amended by Recommendation 09:2015 and Recommendation 10:2018, 2018, art. 8).

Similarly to APEIs, VMEs are sectoral tools, offering protection only from bottom-fishing activities and their impacts. However, they are also of relevance for the management of deep-sea mining activities, as their identification criteria could be relied upon to assess what sites could be characterized as sites/areas in need of protection/precaution under the draft nMAR REMP (Gollner et al., 2021). This also calls for the strengthening of a multi-sectoral dialogue, questions further discussed below.

The second tool, developed in the context of the Convention on Biological Diversity (CBD), is the Ecologically and Biologically Significant Areas (EBSAs) process. The EBSA process "is a global scientific and technical process" (Diz et al., 2017, p. 8) that aims to identify and collect information about specific areas of the ocean having special importance for ecological and biological processes (Workshop "Protecting deep seabed ecosystems under the future Agreement on the Conservation Sustainable Use of BBNJ by the ISA–Perspectives of Government, Civil Society, Stakeholders, and Law and Science", 2021; EBSA). This identification process uses a set

5 The International Maritime Organization (IMO) has also created ABMTs in the form of Particularly Sensitive Sea Areas (PSSAs), areas "that needs special protection through action by IMO because of its significance for recognized ecological or socio-economic or scientific attributes where such attributes may be vulnerable to damage by international shipping activities" (Revised Guidelines for the Identification Designation of Particularly Sensitive Sea Areas, 2006, pt. Annex, para 1.2) Despite (1) the similarities between the PSAAs identification criteria and the ones described below for VMEs and EBSAs, and (2) the relevance of PSSAs for the broader discussion on ABMTs, the present paper does not address PSSAs as none has so far been declared in ABNJ (De Santo, 2018, p. 35) nor are the existing PSSAs found in current areas of interest for deep-sea mining activities.

6 The criteria are:

1) uniqueness or rarity, i.e. "contains rare species whose loss could not be compensated for by similar areas or ecosystems";

2) functional significance of the habitat, i.e. "that are necessary for the survival, function, spawning/reproduction or recovery of fish stocks"; 3) fragility, i.e. "highly susceptible to degradation by anthropogenic activities";

4) life-history traits of component species that make recovery difficult, i.e. species that have, e.g., "low growth rates, late age of maturity, low or unpredictable recruitment; or long-lived"; and

5) structural complexity, i.e. "complex physical structures [where] ecological processes are usually highly dependent on these structured systems."

of seven criteria, which present many similarities with the VME criteria[7]. The assessment of EBSA criteria also contains a strong interaction with the way one defines and assesses the scope of serious harm to the marine environment (Levin et al., 2016a; Mengerink, 2018). In fact, such assessment relies on a combination between the extent, duration/frequency, intensity/magnitude and probability of harm, the vulnerability of the site, and cumulative effects (Workshop "Protecting deep seabed ecosystems under the future Agreement on the Conservation Sustainable Use of BBNJ by the ISA–Perspectives of Government, Civil Society, Stakeholders, and Law and Science", 2021).

An EBSA designation can then support the need for a management measure in the area, such as marine protected areas or other effective area-based conservation measures. Yet, contrary to VMEs, which are *intended* to lead to the adoption of conservation and management measures to protect vulnerable marine ecosystems, no similar intention can be derived from an EBSA designation. Management measures flow from other international obligations (e.g., art. 194(5) UNCLOS), while the EBSA designation simply acts as a scientific and technical basis for the establishment of such measures. The two are however linked to some extent: as explained by Diz et al. (2017), the "modification of described areas can have implications when the EBSA description has been used as a basis for the implementation of management measures pursuant to other international legally binding obligations" (Diz et al., 2017, p. 8).

This difference between an EBSA designation and the establishment of conservation and management measures can be illustrated by the case of the Lost City hydrothermal vent. Located on the nMAR, the Lost City, along with many other sites in the area, was identified as an EBSA in 2014 (Report of the North-West Atlantic Regional Workshop to Facilitate the Description of Ecologically or Biologically Significant Marine Areas, 2014, pp. 107–122). The site was also "recognized in the world heritage reports for its potential outstanding universal value in the high seas" (Gollner et al., 2021, p. 9). Yet, a deep-seabed mining exploration contract was granted to Poland in 2018 for that area, "based on a recommendation of the ISA's [LTC], which did not specify any particular environmental concerns" (Christiansen et al., 2022, p. 9). Commentators have heavily criticized this decision, mentioning that this situation stemmed from the fact that non-use values (e.g., natural beauty or aesthetic importance), which, along with the seven EBSA criteria, strongly characterizes the Lost City, are not taken into consideration in ISA assessment procedures before granting exploration contracts (Workshop "Protecting deep seabed ecosystems under the future Agreement on the Conservation Sustainable Use of BBNJ by the ISA–Perspectives of Government, Civil Society, Stakeholders, and Law and Science", 2021). It remains to be seen whether the Lost City and other EBSAs on the nMAR will become protected through measures in the newly developed draft nMAR REMP.

EBSA criteria certainly consider connectivity between species and their habitats, as well as the importance of this connectivity for overarching natural processes. Consequently, they are powerful justification tools upon which to rely to establish management measures. Whether this connectivity is replicated at the regulatory and management levels, however, seems to remain the result of a compromise between scientific evidence and other considerations (which, to some extent, reminds us of the case of some CCZ APEIs which had been modified from initial scientific evidence to accommodate exploration licenses already authorized).

Development of ABMTs for the regional environmental management plan for the northern mid-Atlantic ridge

Ecological considerations for ABMTs to protect active vent ecosystems

Three exploration contracts for polymetallic sulfides are issued along the nMAR, and four in the Indian Ocean. In these contract areas, some of the most of pristine and remarkable ecosystems on Earth are located: hydrothermal vents (Figure 1).

Deep-sea hydrothermal vent fields are unique ecosystems, where so-called chemoautothroph microbes gain their energy from chemicals from the vent fluids as opposed to sunlight, and create abundant food for a unique fauna. Globally, the vent ecosystem is a rare habitat, covering only an estimated area of 50 square kilometers, and meeting all scientific rationales for protection (Van Dover et al., 2018; Gollner et al., 2021). The small but unique and biomass rich deep-sea vent ecosystems are found patchily distributed in an otherwise typically food-depleted deep sea, where food mostly originates from the biomass produced *via* sunlight and photosynthesis in the ocean surface waters (Smith et al., 2008). In the past seen as isolated oases in the deep sea, recent evidence suggests that vents influence their surrounding areas: there are large transition zones harboring a mixture of vent fauna, as well as species from the surrounding deep sea that are utilizing the resources generated at these sites (Gollner et al., 2015; Levin et al., 2016b; Georgieva et al., 2020; Haalboom et al., 2020; Klunder et al.,

7 The criteria are:

1) uniqueness or rarity;

2) special importance for life history stages of species;

3) importance for threatened, endangered or declining species and/or habitats;

4) vulnerability, fragility, sensitivity, or slow recovery;

5) biological productivity.

6) biological diversity.

7) naturalness.

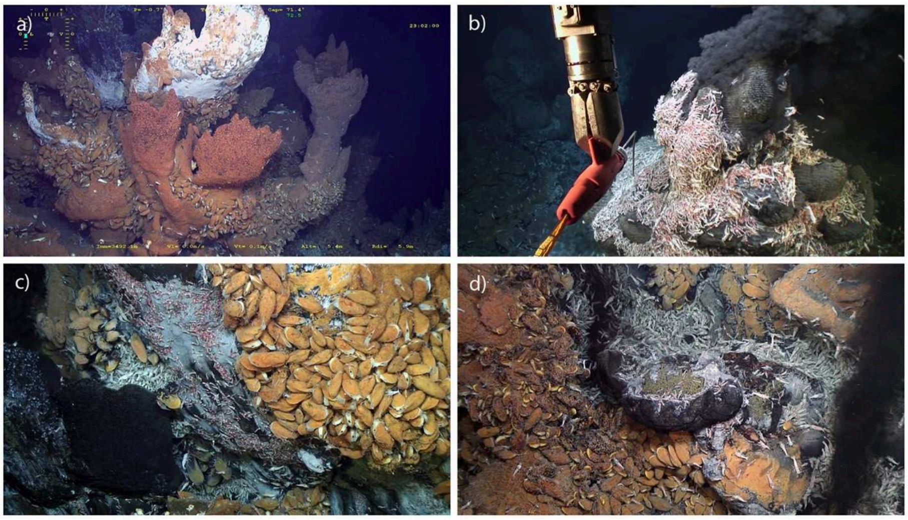

FIGURE 1
Snake Pit vent field in 3350–3500 meters depth at the northern Mid-Atlantic Ridge. Pictures show the structural diversity of mineral deposits [for example active black smoker in **(b)**] and endemic animals which rely on the energy of the vent fluids: **(a)** mussel assemblages, **(b)** shrimp swarms, **(c)** juvenile shrimp swarms and mussels, **(d)** gastropods surrounded by shrimp and mussels. BICOSE 2014 cruise copyright Ifremer. Video of **(a,b,d)** is available at https://doi.org/10.17882/74349. Figure replicated from Gollner et al. (2021).

2020; Cordes et al., 2021; Roohi et al., 2022). To identify the three-dimensional transition zone and thus the management measures to protect active vents, the physical, chemical and biological links need to be measured.

There is a high need for environmental researchers to work on characterizing the transition of the physical habitat, communities and ecosystem functions. For example, they should explore questions such as "are there species overlaps between active vent and surrounding areas?" or "what is the origin of food source?" or "what is the productivity and how does it change?" or "where are the subsurface channel that may connect vent fluids to inactive vents?" (Cordes et al., 2021). The ultimate goals are to determine the three-dimensional sphere of vent influence at each vent field, and to suggest methods for baseline surveys so that the full geographical scope of a vent is covered. The definition of the vent transition zones may be further linked to any network criteria, i.e., with regard to connectivity between vent fields, that is typically achieved *via* particle (such as animal larvae) transport with the natural vent plume and ocean currents from one vent field to the other (Adams et al., 2012; Van Dover et al., 2012; Mullineaux et al., 2018).

Potential ABMTs under the ISA framework for polymetallic sulfide deposits

In accordance with the Council's decision to "develop REMPs in priority regions where exploration activities take place" (Preliminary strategy for the development of regional environmental management plans for the Area, 2018; Implementation of the Authority's strategy for the development of regional environmental management plans for the Area, 2019), an LTC working group developed a draft REMP for the nMAR (Draft regional environmental management plan for the Area of the northern Mid-Atlantic Ridge (MAR) with a focus on polymetallic sulphide deposits, 2022). The draft was published in April 2022 and remained open for stakeholder consultations until early June 2022. The LTC circulated a revised version of the REMP in early October 2022 (Regional environmental management plan for the Area of the northern Mid-Atlantic Ridge (MAR) with a focus on polymetallic sulphide deposits–Issued by the Legal Technical Commission, 2022).

The ABMTs included in the REMP are largely inspired by–or even replicate–suggestions made at expert workshops held in 2018 in Szezin, Poland (Workshop for Developing a Framework for REMPs for Polymetallic Sulphide Deposits in Mid-Ocean Ridges, 2018), 2019 in Evora, Portugal (Report of the Workshop on the Regional Environmental Management Plan for the Area of the Northern Mid-Atlantic Ridge, 2019), and 2020 online (Report of the Workshop on the Development of a Regional Environmental Management Plan for the Area of the Northern Mid-Atlantic Ridge with a Focus on Polymetallic Sulphide Deposits, 2020). It is also worth noting that the

> REMP does not include ABMTs identified through the application of network criteria such as representativity and connectivity. It is noted that further work will be needed on the application of such criteria.

> (Regional environmental management plan for the Area of the northern Mid-Atlantic Ridge (MAR) with a focus on polymetallic sulphide deposits–Issued by the Legal Technical Commission, 2022 para. 33).

Network criteria, discussed in a 2018 study (Dunn et al., 2018) have therefore not been taken up in the draft (Christiansen et al., 2022, p. 9) nor the revised version. This lacuna is of significance for our discussion, as connectivity is also assessed through network criteria (Dunn et al., 2018, pp. 4 and 9).

Three types of area-based management measures are presented in the nMAR REMP: areas and sites in need of protection (AINPs and SINPs, or S/AINPs), as well as sites and areas in need of precaution (S/A Precaution). The REMP identifies 3 AINPs, 11 SINPS and 12 S/A Precaution (Regional environmental management plan for the Area of the northern Mid-Atlantic Ridge (MAR) with a focus on polymetallic sulphide deposits–Issued by the Legal Technical Commission, 2022, paras 40, 45 and 49). This means that these sites or areas have been identified as requiring the level of protection or precaution established by each tool.

AINPs are "large-scale areas of ecological importance due to their uniqueness and/or biodiversity" (Regional environmental management plan for the Area of the northern Mid-Atlantic Ridge (MAR) with a focus on polymetallic sulphide deposits–Issued by the Legal Technical Commission, 2022, para. 37), aiming to protect ecosystem features at the regional scale (Regional environmental management plan for the Area of the northern Mid-Atlantic Ridge (MAR) with a focus on polymetallic sulphide deposits–Issued by the Legal Technical Commission, 2022, para. 38). The management measures for such areas are (Regional environmental management plan for the Area of the northern Mid-Atlantic Ridge (MAR) with a focus on polymetallic sulphide deposits–Issued by the Legal Technical Commission, 2022, para. 39):

- Protection from direct and indirect impacts of mining;
- Protection as an integrated system; and
- Zoning system, including a core zone of full protection, buffer zones, and possibly other zones where some compatible activities could be allowed.

SINPs are "fine-scale sites described on an individual basis," aiming to manage activities that would have serious harmful effects (Regional environmental management plan for the Area of the northern Mid-Atlantic Ridge (MAR) with a focus on polymetallic sulphide deposits–Issued by the Legal Technical Commission, 2022, para. 41). Management measures include (Regional environmental management plan for the Area of the northern Mid-Atlantic Ridge (MAR) with a focus on polymetallic sulphide deposits–Issued by the Legal Technical Commission, 2022, para. 43):

- Protection from direct and indirect impacts of mining (contractors will have to provide sufficient information to prove this protection);
- Delineation and description, by contractors guided by the LTC, of SINPs falling within their contract areas; and
- Zoning system (similar as under AINPs).

Finally, S/A Precaution are either fine-scale sites or large-scale areas having "been predicted to have features that may give the site/area important conservation value" (Regional environmental management plan for the Area of the northern Mid-Atlantic Ridge (MAR) with a focus on polymetallic sulphide deposits–Issued by the Legal Technical Commission, 2022, para. 46). The REMP spells out a procedure for 'upgrading' an S/A Precaution to a S/AINP or for removing the S/A Precaution status (Regional environmental management plan for the Area of the northern Mid-Atlantic Ridge (MAR) with a focus on polymetallic sulphide deposits–Issued by the Legal Technical Commission, 2022, para. 47). The REMP finally calls upon contractors planning to undertake exploitation activities to apply a precautionary approach, and to not start such activities in an S/A Precaution until their status is assessed (Regional environmental management plan for the Area of the northern Mid-Atlantic Ridge (MAR) with a focus on polymetallic sulphide deposits–Issued by the Legal Technical Commission, 2022, para. 48).

Discussion

Outstanding questions impacting on the readiness of the nMAR REMP

Although S/AINPs and S/A Precaution, and the REMP more generally, were acknowledged for making good progress and for representing a good basis upon which to develop further work, they fall short of "clarity regarding obligations, roles, and responsibilities" (USA Comments–Stakeholder consultation on the draft regional environmental management plan for the Area of the northern Mid-Atlantic Ridge with a focus on polymetallic sulphide deposits, 2022; Pew Charitable Trusts–Stakeholder consultation on the draft regional environmental management plan for the Area of the northern Mid-Atlantic Ridge with a focus on polymetallic sulphide deposits, 2022; Germany–Stakeholder consultation on the draft regional environmental management plan for the Area of the northern Mid-Atlantic Ridge with a focus on polymetallic sulphide deposits, 2022, para. 2; DOSI–Stakeholder consultation on the draft regional environmental management plan for the Area of the northern Mid-Atlantic Ridge with a focus on polymetallic sulphide deposits, 2022; Italian delegation–Stakeholder consultation on the draft regional environmental management plan for the Area of the northern Mid-Atlantic Ridge with a focus on polymetallic sulphide deposits, 2022). Similar concerns were reiterated by members of the Council, non-members and observers at the third part of the Council's 27th session in November 2022. These deficits trigger an important number of questions, especially when trying to understand the function of ABMTs and their foreseen implementation[8]. A selected number of questions are discussed below.

1) Identification/establishment/implementation

The identification of S/AINPs relies on similar criteria (Regional environmental management plan for the Area of the northern Mid-Atlantic Ridge (MAR) with a focus on polymetallic sulphide deposits–Issued by the Legal Technical Commission, 2022, sec. Annex IV). However, it is unclear whether the processes for their establishment are similar. It is also not clear who establishes the S/AINPs once the conditions are identified (e.g., it seems to be the contractors to some extent for the SINPs, and it is not specified for AINPs). Should there be a standardized process led by the LTC, in consultation with the scientific community, or by a scientific committee[9]? By giving too much leeway to contractors, we could have a similar situation as with RZs, which, left in the hands of contractors, could lead to great disparities in terms of measures. It is furthermore not always clear how and by whom the management measures are going to be implemented and enforced, i.e., by the ISA, the sponsoring State, or the contractor.

2) AINPs vs. APEIs

It is unclear what differentiates an AINP from an APEI. Is it because different scientific criteria exist to identify them? Is it because, as the nMAR is very different from the CCZ, we use another concept to highlight this distinction? The authors recognize that REMPs have a regional role and must represent the particularities of a specific region, but, as the ISA also has a global mandate, using similar tools and vocabulary could help streamline the obligations that the ISA has toward all regional environments. Furthermore, are legal obligations stemming from an AINP designation different from an APEI designation? Both tools seem to lead to similar obligations as an APEI is an area closed to mining activities (Environmental Management Plan for the Clarion-Clipperton Zone, 2011, para. 39(a)) while AINPs "will be protected from direct or indirect impacts" of mining; yet, the different terminology could lead to concluding otherwise.

3) How do AINPs, SINPs and S/A Precaution interact and/or relate to one another?

Could a certain number of SINPs lead to the creation of AINPs? Further, activities seem to be allowed in S/A Precaution, at least to some extent, as the REMP requires "[c]ontractors planning to undertake exploitation activities in the S/A Precaution [to] apply a precautionary approach" and "not start exploitation activities until [their] status is assessed" (Regional environmental management plan for the Area of the northern Mid-Atlantic Ridge (MAR) with a focus on polymetallic sulphide deposits–Issued by the Legal Technical Commission, 2022, para. 48). It is however unclear what this entails. Does this mean that the management measures established for S/AINPs, especially the protection from direct and indirect impacts of mining, should be applied to S/A Precaution until their status is assessed? We also question through what other methods the precautionary approach could be applied in this situation.

4) The need to fully respect the rights and obligations of contractors when applying management measures for SINPs

The draft REMP originally mentioned that management measures for SINPs must fully respect the rights and obligations of contractors in the existing contracts for exploration (Draft regional environmental management plan for the Area of the northern Mid-Atlantic Ridge (MAR) with a focus on polymetallic sulphide deposits, 2022 para. 40). Although this phrasing has been removed in the revised text, we believe that its previous inclusion warrants a short discussion. What would have this respect entailed for the protection of the marine environment? Could this full respect for the rights and obligations of contractors have been interpreted as giving priority to those rights and obligations over management measures and, consequently, the protection of the marine environment? It is difficult to understand the meaning and impact of these words, as the need to "fully respect" is not found under UNCLOS nor the Part XI Agreement. Aligning the wording of the REMP with terminology used under UNCLOS and the Part XI Agreement could provide clarification. For example, the use of due regard, which ensures a balancing exercise, could entail, e.g., that the management measure of a SINP do not block exploitation activities in other parts of the contract area. Similarly, the idea of "full cooperation," which is used with regards to the transfer of technology (Agreement relating to the implementation of Part XI of the United Nations Convention on the Law of the Sea of 10 December 1982, 1994, sec. Annex, Section 5, para 1(b)), could be replicated to ensure

8 Some of the questions discussed in the text are inspired by the questions found in the submission by Pew Charitable Trusts. Other questions stem from reflections and observations made by the researchers in the project, which have in part been reflected in the submission by DOSI.

9 A standardized process has been suggested by Germany, the Netherlands and Costa Rica (Procedure for the development, 2020).

cooperative actions from all relevant parties, including the contractor. Overall, such alignment with existing terminology should be ensured throughout the text of the REMP to warrant that the protection of the marine environment does not come in second place.

5) (The absence of) network criteria

If network criteria have not yet been established, does this mean the adoption of the REMP can still go ahead? A new regulation in the Draft Exploitation Regulations suggests that a REMP should be adopted before an application for a plan of work can be considered (Facilitator's Revised Text : Draft regulations on exploitation of mineral resources in the Area–Parts IV VI related Annexes, 2022, r. 44bis(3)). Does this mean that an application for a plan of work could be considered based on an adopted REMP that does not include network criteria? The management measures for AINPs indicate that "each of them will be protected as an integrated system" (Regional environmental management plan for the Area of the northern Mid-Atlantic Ridge (MAR) with a focus on polymetallic sulphide deposits–Issued by the Legal Technical Commission, 2022, para. 39b)). Is this a stepping stone to later on build a system at the network level, or, on the contrary, an inhibitor of a network, as each AINP is to be considered as a system in itself?

6) (The absence of) the size of SINPs

The draft nMAR REMP lists 11 SINPs, covering the known active vent fields. However, at the time of writing, the draft REMP only gives, single point coordinates, and the actual delineation of the sites is left to contractors (Draft regional environmental management plan for the Area of the northern Mid-Atlantic Ridge (MAR) with a focus on polymetallic sulphide deposits, 2022, para. 40(b)). The revised text does not seem to provide more guidance on the size or extent of SINPs (Regional environmental management plan for the Area of the northern Mid-Atlantic Ridge (MAR) with a focus on polymetallic sulphide deposits–Issued by the Legal Technical Commission, 2022, paras 43 and Annex II). Considering the ecology of hydrothermal vents it is of upmost importance to robustly determine the three-dimensional sphere of vent influence at each vent field and to protect this space. Otherwise, the goal to protect unique vents is programmed to fail. Cooperation between scientists and contractors will be crucial, as the scientific field of studying and understanding the sphere of vent influence is just developing. Ecological connections between vents and the surrounding areas need to be unraveled and translated to ABMTs, including SINPs.

All these questions highlight the work that remains to be done to clarify the nature, role and impact of the suggested ABMTs in the nMAR REMP. The revised version of the REMP was circulated by the LTC prior to the third part of the Council's 27th session in November 2022, with the hope that it would be adopted during that session. However, on 11 November 2022, the Council, although acknowledging the progress made, considered that the document needed to be developed further before it is ready for adoption. It therefore remains to be seen in which direction the discussions on the nMAR REMP will go in upcoming sessions of the Council, also in light of the discussions on the *Guidance to facilitate the development of regional environmental management plans*, which aim to provide "a standardized approach for the development, approval and review of [REMPs] in the Area, including a template with indicative elements" (Guidance to facilitate the development of regional environmental management plans, 2022).

Beyond ecological connectivity: connectivity among international instruments, institutions and processes

One way to ensure that legal/regulatory instruments and sectoral measures address ecological connectivity is to connect different regulatory and policy components of oceans conservation and management so that they do not stand alone. The ISA has, to some extent, developed partnerships with other entities mandated with the regulation of activities at sea. For example, the ISA entered into an Agreement of Cooperation with the International Maritime Organization, which aims to increase consultations on matters of common interests to ensure maximum coordination and exchange of information in fields of common interest (Agreement of Cooperation between the International Maritime Organization (IMO) and the International Seabed Authority (ISA), 2016, paras 1–2). The ISA has however not joined the Collective Arrangement for the North-East Atlantic that among other goals, seeks "cross-sectoral practical implementation of [...] conservation objectives" in selected areas in ABNJs (Christiansen et al., 2022, p. 7), to which only NEAFC and OSPAR are currently parties (Collective arrangement between competent international organisations on cooperation coordination regarding selected areas in areas beyond national jurisdiction in the North-East Atlantic, 2014). Joining such Arrangement could be beneficial to coordinate different sectoral objectives and measures, in order to give a cross-sectoral and cross-zonal (i.e., deep seabed and water column) coverage of hydrothermal vents and other relevant features, especially considering that the region is under exploration contracts (Exploration Contracts). As the creation of collaborations with other entities is listed as one of the strategic objectives of the ISA in its 2019-2023 Strategic Plan (Strategic Plan of the International Seabed Authority for the Period 2019–2023, 2018, sec. Direction 1.2), the ISA may actively seek to formalize partnerships with entities operating in the same regions.

When addressing issues of spatial management in ABNJ, one cannot ignore the negotiations currently underway to develop an

Implementing Agreement under UNCLOS for the conservation and sustainable use of marine biodiversity beyond national jurisdiction (BBNJ process). Many overlaps exist between this process and the work of the ISA, not only geographically (the BBNJ process covers all ABNJ, including the Area), but also in its subject-matter. The BBNJ process indeed generally aims to improve coordination and cooperation among different uses, institutions and measures in ABNJ, and, more specifically, one of the four core issue-areas covered by the process are ABMTs (International legally binding instrument under the United Nations Convention on the Law of the Sea on the conservation sustainable use of marine biological diversity of areas beyond national jurisdiction, 2017, para. 2).

How, then, could we take advantage of these concurrent developments to strengthen mechanisms in each process, but also connectivity between processes and their spatial management measures (including ABMTs)? A recent study focuses on ways to strengthen "governance integration and the development of a coherent and collaborative interplay between" the BBNJ process and ISA instruments (Christiansen et al., 2022), suggesting that connectivity in governance can be truly operationalized through an ecosystem approach to management (EAM) (Christiansen et al., 2022, p. 2–3). EAM targets natural dynamics and connectivity through a cross-sectoral and long-term vision, the consideration of cumulative impacts and effects, adaptive management, and stakeholder involvement (Long et al., 2015; Christiansen et al., 2022, p. 4).

A challenge however, often raised by delegates in both the BBNJ process and the ISA fora, is to implement an EAM in practice. One option, the study suggests, is to explore how REMPs could be used as vehicles to operationalize an EAM, which would help align REMPs with BBNJ objectives and measures. Different policy recommendations are made to that effect (Christiansen et al., 2022, p. 17), three of which are of direct relevance to shape new and/or strengthening existing ABMTs in a way that addresses ecological connectivity.

First, ambitious principles and goals could direct coordination between objectives and processes (Christiansen et al., 2022, p. 12). In the specific context of the ISA, developing strategic environmental goals and objectives (SEGOs), complemented by clear targets and indicators, has been identified as necessary to properly assess "progress toward meeting those objectives" (Tunnicliffe et al., 2020, p. 7; Singh, 2021, p. 3). General objectives and/or guiding principles for marine environmental protection and management are found in the ISA Draft Exploitation Regulations (Facilitator's Revised Text : Draft regulations on exploitation of mineral resources in the Area–Parts IV VI related Annexes, 2022, r. 44), in the CCZ REMP (Environmental Management Plan for the Clarion-Clipperton Zone, 2011, para. 13), in the nMAR REMP (Regional environmental management plan for the Area of the northern Mid-Atlantic Ridge (MAR) with a focus on polymetallic sulphide deposits–Issued by the Legal Technical Commission, 2022, paras 12–13), and in the BBNJ draft text, both for the agreement as a whole and for ABMTs more specifically (Further revised draft text of an agreement under the United Nations Convention on the Law of the Sea on the conservation sustainable use of marine biological diversity of areas beyond national jurisdiction, 2022, arts. 5, 14 and 17(1)(a)). These are good stepping stones, but the necessary SEGOs would have more ambitions and a "higher purpose" for all initiatives linked to the conservation and management of the marine environment. SEGOs could also help align deep-sea mining environmental efforts subject to art. 145 UNCLOS with other processes which have similar goals, including the BBNJ process (Workshop "Protecting deep seabed ecosystems under the future Agreement on the Conservation Sustainable Use of BBNJ by the ISA–Perspectives of Government, Civil Society, Stakeholders, and Law and Science", 2021). ABMTs could be designed in order to fulfill these goals, embedded in a cross-sectoral and cross-zonal strategy.

Second, REMPs, and management tools included therein, should always respect–and even align with–existing identifications and designations, e.g., VMEs and EBSAs. One step further would be to ensure that the designation of ABMTs by the ISA also relies on the same/similar criteria as the one used for VMEs and/or EBSAs, which are also used as "indicative criteria for identification of" ABMTs found in Annex I of the draft BBNJ text (Further revised draft text of an agreement under the United Nations Convention on the Law of the Sea on the conservation sustainable use of marine biological diversity of areas beyond national jurisdiction, 2022). This "alignment" exercise could moreover complement the standardized approach to the development of REMPs suggested by Germany, the Netherlands and Costa Rica in their joint 2020 submission (Procedure for the development, 2020).

Finally, pursuing an EAM to guide the design of "connectivity-friendly" ABMTs would reiterate the importance of stakeholder involvement. Hosting a consultation with stakeholders following the publication of the draft nMAR REMP is one positive way forward; yet, it is unsure whether stakeholder input will be sought on revised versions of the draft. Stakeholder engagement is necessary at all stages of the process, and it would furthermore be a way to warrant the consideration of conflicting oceans uses and interests that might impact on the effectiveness of a sector-specific ABMT (Christiansen et al., 2022, p. 7).

As the regulatory framework for the protection and management of different areas and resources of the oceans remains fragmented (and, as the BBNJ negotiations have shown, this division is strongly protected by existing institutions, who often fiercely guard their respective mandate), the policy suggestions discussed above are ways to find synergies among instruments, institutions and processes. Facilitating this type of connectivity therefore contributes to embedding the highest possible environmental standards in ISA regulation and practice (Hydrothermal vent fields: Protecting deep seabed hydrothermal vent fields through area-based management tools).

Conclusion

ABMTs developed by the ISA can only partly cover connectivity between the deep seabed and the water column. This flows from the definition of "marine environment" found under the Draft Exploitation Regulations, as well as the role of the different tools, which aim to protect from and/or monitor the *impacts* of deep-seabed mining, which are likely to also occur in the water column. However, uncertainties with regards to the exact nature and scope of existing tools limit a full understanding of their functioning. There is a clear need to identify the ecological transition zones of vents, so that the sphere of vent influence can be determined in practice and thus a three-dimensional space that would need protection can be assigned. Furthermore, the impossibility for sectoral organizations to develop truly cross-sectoral tools restricts the full three-dimensional potential of current spatial management. The ISA will therefore need to continue its work to ensure that the environmental protection pillar of its mandate is truly fulfilled.

As part of their overarching objective to translate ecological connectivity into regulatory mechanisms, researchers and decision-makers might have to delve into broader and more holistic governance mechanisms and processes, in order to reflect the necessary connectivity that also exist between international instruments, institutions and processes. Exploring alternative and complementary types of governance, such as polycentricity (Gjerde and Yadav, 2021; Dalaker, 2022), a "governance that is characterized by multi-scale governing authorities, institutions, and bodies rather than a centralized governing body" (Ostrom, 2010; Dalaker, 2022, p. 37), is also necessary.

Author contributions

CB drafted the article. SG contributed to the writing. Both authors approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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