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Deep-seabed mining: an environmental concern and a holistic social environmental justice issue

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This study provides an update on the current regulatory and institutional landscape of deep-seabed mining (DSM). This regime formation occurred at a unique historical moment characterized by noteworthy legal developments. This is primarily because it applies to an activity (exploitation) that has not yet commenced but is anticipated to commence in the near future, contingent on the finalization of the regulatory regime. The legal environmental framework of DSM presents numerous challenges and gaps; however, it also has potential significance, particularly in the context of the ongoing green energy transition. This study aims to examine the intricate interplay between law and technology, looking at the “law in context” within the broader context of justice and geopolitics and the environmental framework of the DSM industry and seeks to address the existing regulatory gaps. This underscores the importance of adopting a precautionary approach and advocates the meticulous determination of the appropriate type of precautionary approach to be employed in the future. By holistically scrutinizing DSM environmental law and policy and using the European Union and the Arctic as geopolitical-legal case studies, this article underscores that DSM is an environmental concern and a social environmental justice issue.

KEYWORDS

deep seabed mining law and governance, common heritage of mankind, common concern of humankind, precautionary approach, environmental justice, law and technology, sustainable green energy transition, Arctic environmental law and geopolitics

1 Introduction

Deep-seabed mining (DSM) presents a rare opportunity to address the climate crisis by providing essential minerals for the transition from fossil fuels to batteries, which can power a significant number of electric vehicles. The supply of critical minerals, such as copper, manganese, and cobalt, is crucial for advancing clean energy technology. However, DSM occurs in a unique area that cannot be treated, regulated, and managed as other marine environments. Here is the dilemma. The European Union pushed for a *moratorium* on DSM (EU, 2018); however, it continues to fund research on the impact of DSM and environmentally friendly technologies.

The “Area” is unique, a global common, defined as “common heritage of mankind,” and is regulated by the 1982 United Nations Convention on the Law of the Sea (UNCLOS; Article 136), although not updated to regulate DSM activities, and by the International Seabed Authority (ISA), a UN organization that regulates, manages, and administers the Area (UNCLOS, Article 157).

Until now, there has been a gold rush to the ocean floor occurring under a set of environmental legislations, however with lax environmental regulations and standards, particularly because there is at present significant scientific *uncertainty* regarding the environmental impacts (IUCN, 2019; MacMaster, 2019; Leal Filho et al., 2021; Levin, 2021; Christiansen et al., 2022; EASAC Report, 2023; Environmental Justice Foundation, 2023; Heffernan, 2023). This uncertainty is not only in terms of environmental science but also in terms of legal, ethical/justice, and geopolitical issues, all of which are fundamental factors in environmental regime effectiveness. For example, there is no legal definition of environmental damage or DSM thresholds to ascertain whether environmental damage is a consequence of DSM activities. What if there was an accident caused by DSM activity in the deep sea? How does one place responsibility? Until now, such a scenario has not occurred in the exploitation phase; however, a parallel can be drawn to major accidents of mining on land that occurred in the past. Some authors have argued that the DSM is a desirable alternative to terrestrial mining (Batker and Schmidt, 2015).

Both DSM (would) and land mining (does) inevitably disturb what would otherwise be a pristine environment. This leads to environmental impacts and other issues that must be addressed throughout the mining cycle. Both can lead to the loss of biodiversity and disruption of ecosystems. With respect to terrestrial mining, we are acquiring an understanding of how to remediate legacy issues and plan for their closure to best mitigate issues such as the loss of biodiversity or other impacts. We do not yet have the same level of understanding of the impact and “mine closure” that would arise from DSM. Indeed, a recent *Planet Tracker* report (Planet Tracker, 2023) from June 2023 concludes that “*deep sea ecosystems are essentially unrestorable*” and calculates that “[t]he cost of [deep sea] restoration [from DSM] would be so high that it would be impossible for deep sea mining companies to pay for it and operate at a profit.” Major mining accidents occur for various reasons, including regulations being ignored. In addition to causing the loss of human life, accidents have resulted in significant environmental disasters.

Two examples include the Report (1973) and IUCN (2018). The Buffalo Creek Disaster was one of the worst mining accidents in West Virginia, USA, in which three impoundment dams holding wastewater from coal mining burst in succession, causing a flood that killed 125 people, injured over 1,100 people, and destroyed numerous homes. The damage to the environment was also extensive: more than 30 years passed before the fish population killed in the Buffalo Creek waters, which were toxic from the spill, could be restocked (Asterra, 2023). The Fundão Dam collapsed in Minas Gerais, Brazil, releasing 50 million tons of toxic tailings into the Doce River.

It was “*the nation’s worst environmental disaster ever*” (Sullivan, 2017). Owing to the nascent stage of DSM, there have not yet been environmental disasters at sea, such as those that have occurred in

the oil and natural gas sectors. However, an incident occurred in 2021 during the world-first experiment: a 25-ton mining tractor (*Patania II*) broke free of its tether and was stranded more than 4 km below the surface (Reuters, 2021) until a remote underwater vehicle could assist engineers in recovering it (Reuters, 2021).

These examples underscore the importance of enforcing stringent safety regulations and practices in mining operations to prevent accidents and mitigate their environmental impacts. It is crucial to understand and manage these risks to protect human life and the environment. The legal consequences of mining accidents that cause damage to the environment vary by jurisdiction; however, in most cases, they can include significant fines and imprisonment.

Despite such uncertainty, in January, the ISA, also known as the “Authority,” an international body of the United Nations that acts on behalf of humanity, had already granted 30 contracts of exploration; however, exploitation has not begun yet because the ISA has not finalized its regulations, which are expected in 2025 (International Seabed ISBA, 2023). This study aims to assess, for the first time, which type of precautionary approach is more appropriate within the context of a holistic and “complex regime”¹ such as the one of DSM. This holistic perspective necessitates integrating legal analysis (analyzing the “law in context”) within its governance context, which includes factors that are important in shaping the formation of the DSM regime and potentially bridging legal gaps. To identify gaps in this regime, interdisciplinarity is required, as law alone cannot explain the complexity and societal challenges of this regime; however, technology and socio-geopolitical components also need to be included.

This study addresses the following research questions: Which type of precautionary approach is desirable in DSM activities, considering that it must encompass factors such as green energy transition, technological advancements, and the future law-geopolitical landscape, and how do regional regimes such as those applied in the European Union and the Arctic impact the approach?

Our study suggests that a redesigned DSM environmental regime should be shaped to eliminate the unjust exploration of deep-sea mineral resources and avoid potential environmental risks associated with DSM activities. We demonstrate the reasonableness of this view by considering the case of the European Union and the Arctic and then explain the application of the law in the context described earlier.

Although the precautionary and geopolitical approaches are two distinct concepts, they can be connected in the context of DSM international, environmental, and energy law. This occurs particularly in areas where global issues, risks, and uncertainties

1 A complex regime is characterized as a compilation of diverse sources of law and policy at multi-regulatory levels spanning multiple cross areas and external factors. These elements interact and overlap, typically addressing issues within a “common issue area.” The sources of law and policy and external factors are not hierarchically related but are integrated within a clearly defined institutional framework. Regulations of such complex regimes often face uncertainty, influenced by the interactions of scientific uncertainties, variabilities, and external factors such as legal, environmental (climate), economic, or social dimension (Young, 2012).

intersect, such as the Arctic, considering the magnitude of climatic and oceanic changes in this region. This case study provides a framework for improving adaptation and mitigation at the planetary level.

In this framework, a precautionary approach may be relevant to discussions on the deployment of new technologies with potential security implications. The link between the precautionary and geopolitical approaches in DSM is necessary to illustrate how geopolitics can contribute to international environmental energy laws and vice versa. This link can explain the conduct of certain states in green energy transition in relation to *space* (spatial dimension), leading to the possible construction of a predictable legal framework in which nations may need to balance geopolitical interests with a precautionary approach to prevent unintended consequences. Moreover, it offers a *temporal* (the future) environmental dimension of a justice perspective, where we facilitate a convergence of the “principle of common heritage of mankind” and the “concept of common concern of humankind,” as explained in Section 2.1.

Cosmopolitan law is also discussed in the context of energy transition, linked to the need to reinforce the proposal to establish a Fund of Compensation (ISBA, 2019) in view of future damage to ecosystems, the management of human activities (the ecosystem management approach, EAM), and the regional environmental management plans (REMPs; Feichtner, 2020; Christiansen et al., 2022).

To sum up, after the Introduction, we provide a status update on DSM law and governance (Section 2), followed by a discussion on the peculiarity of the “Area,” which is the *space dimension* where DSM will be conducted: a special and unique space that cannot be treated as the other marine environments and is defined as the common heritage of mankind.

As the DSM Area is governed in the interests of “humanity,” the subsequent section argues that a new interaction between the principle of common heritage of mankind and the concept of common concern of humankind is underway and needs to be balanced (Section 2.1).

The contextualization of DSM is thus placed in the *temporal* dimension in Section 3, titled “DSM in the Context of Green Energy Transition,” which is followed by an analysis of the institutional actors’ positions: the ISA (Section 4) and the EU (Section 5) in their role in regime formation and the capacity to apply the precautionary approach.

These sections (Sections 4, 5) are followed by an analysis of which type of precautionary approach is desirable in the current, holistic context of green energy transition (Section 6) considering technological advancements (Section 7), the just and ethical dimension (Section 8), and finally in the context of geopolitical-legal aspects with case of the Arctic (Section 9).

In the last section, “Discussion and Conclusion” (Section 10), DSM is related to the current concept of sovereignty, which needs to change and be understood within the perspective of environmental justice and in terms of cosmopolitan law to better understand and balance future interactive applicability between the principle of the common heritage of humankind and the concept of the common concern of humankind for the sake of our global future.

2 DSM law and governance status: an update

Of the Earth’s surface, 70% is covered by the sea. Marine resources provide sustenance for millions of people in terms of food, energy, transportation, and employment. Therefore, the conservation of the marine environment is vital to the general environment and human survival. The deep-seabed ocean comprises areas below 200 m, which are unknown frontiers of scientific knowledge on Earth and hide a multitude of mysteries regarding biodiversity and ecosystem development. DSM generally occurs at 4,000 m in location areas considered common heritage of mankind, in particular in what is defined as “the Area” by UNCLOS (Article 136 UNCLOS). Therefore, activities such as DSM occurring in the Area are subject to the existing international regimes for marine environmental matters that operate on two levels: the first is of a general nature, encompassing customary law and international instruments that establish general principles; the second comprises conventional regimes that impose obligations at both the global (global instruments on pollution, environmental treaties) and regional levels (regional sea treaties), with reference to specific situations and risks.

DSM should be aligned with global goals and recent international agreements, particularly on biodiversity conservation, that is, the goals and targets set by the UN Decade on Ecosystem Restoration, the UN Sustainable Development Goals (SDGs, 2021), and the Kunming-Montreal Global Biodiversity Framework adopted in 2022 (Kunming-Montreal Global Biodiversity Framework, 2022) by the parties to the Convention on Biological Diversity (CBD, 1992). Currently, there are gaps in the legal responses regarding the interactions between DSM and ocean carbon sequestration, the shipping sector, and the new agreement under the UNCLOS on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction (BBNJ Treaty, 2023). At the regional level, it is expected that alignment should also occur between DSM activities and the Nature Restoration Law (EC, 2023) introduced by the European Commission to restore ecosystems for people, climate, and the planet.

UNCLOS regulates the marine environment; however, when drafted, it did not specifically address marine environmental issues. The environmental aspect is particularly relevant to DSM activities, that is, Part XII titled “Protection and Preservation of the Marine Environment,” particularly Article 192, which states that “[s]tates have the obligation to protect and preserve the marine environment.” The scope of this obligation is specified in Article 194, according to which every state must take all necessary measures to ensure that activities within its jurisdiction or control do not cause pollution or harm to other states or extend beyond areas subject to its sovereignty. This principle practically refers to the general legal principle of “*neminem ledere*,” with the crucial obligation not to cause harm extending not only to the territory of other states but also to marine areas not subject to the sovereignty of any state.

Article 194 identifies four sources of pollution that must be addressed: (1) the release of toxic, harmful, or noxious substances from land-based sources, the atmosphere, or by dumping; (2) pollution from vessels; (3) pollution from installations and

equipment used for the exploration and exploitation of the seabed and subsoil; and (4) pollution from other installations and equipment operating in the marine environment. There is a correlation between the mentioned rules to protect the marine environment and the obligation not to pollute, in which the definition of *pollution* is crucial and is defined in Article 1 (4) UNCLOS, Part 1.²

From this definition, UNCLOS does not establish an absolute prohibition on any form of introduction of external agents into the marine environment, only those that, by their nature and intensity, produce or may have harmful effects on the environment and human health. Without explicitly stating as such, it appears to suggest an obligation to assert the precautionary principle. The precautionary principle aims to provide guidance on the applicability of environmental law where there is uncertainty owing to a lack of scientific evidence (Birnie et al., 2009; de Sadeleer, 2010; Gullet, 2021), and it is found, for example, in the Preamble of the Declaration of the Second International Conference on the Protection of the North Sea (Hey, 1991). Failure to comply with obligations to safeguard the marine environment results in the international responsibility of a state, as stipulated in Article 235, Paragraph 1 of UNCLOS.³

The subsequent paragraphs of this article also impose on states the obligation to cooperate in establishing private law mechanisms and adequate compensation for damages caused by pollution through the adoption of uniform rules of civil liability, mandatory insurance, and compensation funds.⁴

In addition to these general rules, the DSM is subject to special regulations within the Area, as previously specified. Beyond the limits of the territorial sea and continental shelf, there are deep-seabed areas that are not under the jurisdiction of any state.

2 Article 1 (4) UNCLOS, Part 1 defines *pollution* as “[p]ollution of the marine environment means the introduction by man, directly or indirectly, of substances or energy into the marine environment, including estuaries, which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities.” Section 9, Responsibility and Liability.

3 Article 235, Paragraph 1 of UNCLOS, states: “States are responsible for the fulfillment of their international obligations concerning the protection and preservation of the marine environment. They shall be liable in accordance with international law.” Section 9, Responsibility and Liability.

4 Article 235, Paragraphs 2 and 3 of UNCLOS state: 2. “States shall ensure that recourse is available in accordance with their legal systems for prompt and adequate compensation or other relief in respect of damage caused by pollution of the marine environment by natural or juridical persons under their jurisdiction.” 3. “With the objective of assuring prompt and adequate compensation in respect of all damage caused by pollution of the marine environment, States shall cooperate in the implementation of existing international law and the further development of international law relating to responsibility and liability for the assessment of and compensation for damage and the settlement of related disputes, as well as, where appropriate, development of criteria and procedures for payment of adequate compensation, such as compulsory insurance or compensation funds.” Section 9, Responsibility and Liability.

The Area has promising prospects for the development of DSM activities for exploration and exploitation. Furthermore, limited scientific knowledge prevents a comprehensive assessment of the potential impacts of these activities on the Area’s ecosystems and climate change. The legal status of the Area is defined in Part XI of UNCLOS, which regulates the conduct of any exploration and exploitation activities of resources and according to Article 136 the Area and its resources are defined common heritage of mankind, which means that the deep sea cannot be appropriated unilaterally but is open to use by the international community. However, this does not mean that anyone or everyone can exploit these resources, as they are precisely regulated; the exploitation of these resources is subject to ISA control. According to a system known as “parallel,” mining activities in the Area can be conducted either by the ISA through a technical entity called the “Enterprise” or through a licensing system granted by the ISA to states or enterprises sponsored by states. Article 145 of UNCLOS stipulates that the ISA must adopt rules and procedures to prevent pollution caused by mining activities in the Area.

Neither UNCLOS nor the ISA provide for a definition of environmental damage and what is a reliable threshold according to which environmental harm can be considered “acceptable or not” and DSM activities not categorized as “hazardous” (activities with high probability to cause environmental harm).

In 2000, the ISA adopted regulations on the prospecting and exploration of polymetallic nodules in the Area, which require the Authority and sponsoring states to apply the precautionary principle to ensure the effective protection of the marine environment from harmful effects that may result from these activities (Article 31 of the Regulation).

For entities obtaining licenses for the exploitation of portions of the Area, referred to as “contractors,” which are entities or organizations that have been approved by the ISA to engage in exploration activities (as those mentioned in the Introduction), Regulation 31 of the Draft Regulations on Exploitation of Mineral Resources in the Area (ISBA, 2019; [Draft Regulation on exploitation of mineral resources in the Area, ISBA/25/C/WP.1, Regulation 31](#)) also mandates the use of the best available techniques to prevent pollution.

The ISA has adopted several regulations for both exploration and exploitation.⁵

The ISA has also adopted regulations for exploration, referred to as “Exploration Regulations.” Currently, the ISA is in the process of officially adopting the Exploitation Regulations, known as the “Draft Regulations on Exploitation of Mineral Resource in the Area,”⁶ which has not yet been finalized. The delay in finalization is attributed to a rule established in 1994, known as “Two-Years Rule,” which mandates that parties “shall complete the adoption of

5 ISA has adopted three types of regulations: (1) [Regulation on Prospecting Exploitation for Polymetallic Nodules \(2000\)](#), UN Doc. ISBA/6/A/28, (2) [Regulation on Prospecting Exploitation for Polymetallic Sulphides \(2010\)](#), UN Document ISBA/16/A/12/Rev. 1, and (3) [Regulation on Prospecting for Exploitation for Cobalt Rich Crusts \(2012\)](#), UN Doc. ISBA/18/A/11.

6 Draft Regulation on Exploitation of Mineral Resource in the Area, ISBA/24/LTC/WP.1/Rev.1, 9 July 2018.

such rules, regulations, and procedures within the 2 years of such a request” (Blanchard et al., 2023). More specifically, the Two-Year Rule refers to a provision of UNCLOS that urges the ISA to finalize its rules, regulations, and procedures for DSM within a 2-year timeframe or grant mining licenses with whatever rules are in place by then. It is noteworthy that this Two-Years Rule is not a process or an agreement of the Council, the executive organ of the ISA⁷; it is a rule established in the 1994 UNCLOS Implementing Agreement. This rule applies only if a member state formally requests the ISA (whose competent body for the adoption of the text of the regulations is the “Council” of the ISA) to adopt those regulations rules and procedures.

At the time of writing, this rule, known as the Two Years Rule is still pending. Therefore, the ISA cannot finalize these rules. Therefore, the development of a regulatory framework for DSM is an ongoing process. Additionally, according to the Exploration Regulations and the “Exploitation Regulations—under development,” DSM activities are regulated by the Mining Code, which is a collection of regulations on DSM (International Seabed Authority, 2024) produced by the ISA, and the recommendations on the protection of the marine environment [UNCLOS, Article 165 (2)]. The Mining Code covers all three mining stages in the Area, which are (1) prospecting, (2) exploration, and (3) exploitation. Each of these three stages is subject to specific environmental requirements (Lodge, 2015).

Several authors assessed the environmental liability regimes of these regulations as weak (Harrison, 2016; Feichtner, 2020; Christiansen et al., 2022; Cassotta and Goodsite, 2023). This weakness was also supported by an advisory opinion in 2011 from the Seabed Dispute Chamber (SDC; Advisory Opinion, 2011).

DSM parties willing to engage in exploration or exploitation in the Area are obliged to submit an environmental impact statement (EIS) when applying for a license. In addition, environmental impact assessments (EIAs) are required to operationalise the EAM of human activities. The ISA has also developed REMPs for regions with emerging DSM potential, which are based on a set of guiding principles, such as the precautionary principle, the principle of prevention, prior impact assessment, and transparency. Despite the existence of the aforementioned EIAs, EAM, and REMPs, a group of authors (Christiansen et al., 2022) advocate that the ISA is weak in fully recognizing EAM as the best management practice to cope with the spatial and temporal effects caused by DSM. An exception lies in the case of the Clarion–Clipperton Zone, where some scholars advocate that certain elements of management practices can be observed in ISA management plans (Christiansen et al., 2022). However, the same authors argue that these elements remain weak and inadequately recognized.

In addition, this case indicates that there could be a “mismatch” between regulatory environmental measures adopted in “theory” and the way they work in “reality” (at the empirical level) once implemented in “practice.” Management of the Clarion–Clipperton Zone is an example of an important environmental protection measure adopted by the ISA. Furthermore, it was adopted despite neither environmental management plans nor protected marine areas being specifically mentioned in the Mining Code (Jaeckel,

2017). In addition, the aim of the plan was to implement a precautionary approach, although this exercise was limited by the fact that it was not adopted before numerous exploration contracts had been granted. This implies that the positioning of the protected areas was altered because some portions of the seafloor earmarked for protection were already committed to exploration contracts. This illustrates that what is encompassed within the ISA environmental measures may not always align with practical implementation, thereby potentially generating a disparity between “law in theory” (*de jure*) and “law in practice” (*de facto*) (Jaeckel, 2017).

EAM is a comprehensive cross-sectorial approach that aims to implement a precautionary approach based on long-term vision, strategic management, and management objectives. However, as presented in the aforementioned Clarion–Clipperton Zone case, a full comprehension of the functioning of the regulatory provisions for DSM in practice will not be feasible until the exploitation phase commences. There is currently a lack of evidence on how regulatory measures operate during the exploitation phase.

However, it would be advantageous to resolve the aforementioned mismatch during the exploratory phase to prevent possible environmental damage during the exploitation phase. Revising the exploratory phase would also be beneficial for the exploitation phase. Therefore, the exploratory phase could be used as a “test” to better prevent environmental damage during the exploitation phase, reinforcing the precautionary approach and allowing adjustments to the regulatory framework currently under review by the ISA. Moreover, this would permit taking stock of what is already happening in the exploratory phase and would develop and redesign the DSM regulatory framework in a more “pro-active law” rather than a “reactive law.”

Several gaps have been identified regarding the lack of clarity on the power of ISA to reject applications based on insufficient EISs (Christiansen et al., 2022). The REMPs do not contain any requirements to have insurance and financial mechanisms in place; however, an Environmental and Performance Guarantee and an Environmental Fund have been envisaged in the Draft Exploitation Regulations,⁸ without specifying how such a fund should be designed and implemented. Environmental financial guarantees cover the costs associated with closing mining sites.

2.1 The principle of common heritage of mankind and the concept of common concern of humankind: a new interaction?

The principle of common heritage of mankind is central in DSM activities and should be clearly distinguished from other two concepts, in particular the concept of “common property,” or “common concerns,” because both concepts deal with “shared natural resources”: the latter is an unclear and controversial concept in several ways, as not every state accepts the concept (Basse, 1997). Natural resources that remain beyond the limits of national jurisdiction can be classified as living and non-living.

⁷ The Council is discussed in Section 4.

⁸ Draft Regulations n. 53, p. 40.

The “living natural resources” found in areas over which states do not have sovereignty, such as the high seas or the airspace above them (e.g., fish, mammals, or migratory birds), are not the property of any specific state. Instead, they are, as defined by the Anglo-Saxon doctrine, common property, and these resources can be exploited by any state in a non-exclusive manner and in accordance with international rules (treaties and judgements) treating global resources regimes for areas and national resources that remained beyond the limits of national jurisdictions.

These rules impose cooperative obligations to ensure the fair use and sustainable exploitation of these resources. If the resources become scarce and several States compete to exploit them, then the general principle of equitable exploitation applies although the notion of equitable exploitation is vague.

Nevertheless, according to a logic which is not completely different, international law experienced the development and evolution of the concept of common property in two different innovative new concepts: the concept of common interest, better known as common concern, and the concept of common heritage, the latter further evolved into a principle, which is the principle of common heritage of mankind (Birnie et al., 2009).

The concept of common concern *tout court* indicates environmental issues that are undoubtedly beyond the exclusive management of individual states, regardless of sovereignty matters, as they are considered of interest to the entire international community. For example, climate change or biodiversity conservation has been defined this way by the Convention on Biological Diversity of 1992 which reaffirms the sovereignty of each State over its biological resources after defining them as a “common concern of humanity” and the United Nations Framework Convention on Climate Change of 1992 that defines the conservation of biological diversity and change in the Earth’s climate and its adverse effects as common concerns of humankind (Schäli, 2019).

From a legal perspective, this concept appears to lead to some significant legal consequences, as presented in Points (1) and (2):

(1) The qualification of common concerns of humankind removes these resources from the “reserved domain” of states. While states retain sovereignty over their own resources, they must conserve and manage them according to international rules established in the interest of all (states are no longer able to claim that it is solely their internal affair); (2) an expansion of the subjective scope of cooperation obligations, where it is no longer limited to states sharing a natural resource or those affected by a specific hazardous activity or the exploitation of common resources but, by definition, extended to *all states* that must cooperate for the common good.

Hence, the attribution “of mankind” qualification clarifies that the resulting obligations are “*erga omnes*” obligations, meaning that *all states* could invoke the responsibility of a state that does not comply. In addition, with the attribution “of mankind,” there is an extra geographical-territorial and normative-institutional dimension (or evolutionary stage) that makes the difference.

The principle of common heritage of mankind applies to areas and *non-living resources* that are outside national jurisdiction. Therefore, an example *par excellence* of collective management, meaning the common heritage of mankind, is the moon and other celestial bodies, as well as the seabed beyond the national jurisdictions of states, particularly the Area (Article 136 UNCLOS

states: “*The Area and its resources are the common heritage of mankind*”), which means that no state may claim or exercise sovereignty or sovereign rights over any part of the Area or its resources, nor shall any state or natural or juridical person appropriate any part thereof. The ISA administers all these resources on behalf of mankind (on behalf of “humanity”) through the adoption of meta-regulatory and institutional regimes aimed at collective management and in the interests of *humanity*.

In principle, all states must share the benefits of these resources, even if they do not necessarily participate in the exploration or exploitation, which underlines the fundamental conceptual international law difference existing between the principle of Common Heritage of Mankind and the other two concepts (common property and common concern of humankind).

Hence, it is not excluded that both the concepts (common concern of humankind and the principle of common heritage of mankind) could apply together, as in the case of Arctic exploration (Dervovic, 2021), considering the magnitude of climatic and oceanic changes in the Arctic. Marine scientific research and seabed mineral exploitation in this region are of particular interest to humankind, as they can improve adaptation and mitigation strategies at a planetary level. What is happening in the Arctic is not limited to the Arctic. We face these challenges for the sake and survival of humanity.

Perhaps, DSM activities in the Arctic will even offer a new opportunity to build up an even further stage in the evolution of international law, resulting in a new legal spatial dimension integrating a concept—the concept of common concern of humankind, with a new principle, the principle of common heritage of mankind. The fusion of these two could be reconceptualised as a new principle of human planetary Earth heritage. This would be appropriate for the anthropogenic era in which we live.

3 DSM in the context of green energy transition

The interests of some countries in considering DSM are currently sparked by the challenges of energy security and geopolitical contexts that have also pushed Europe to accelerate and shape the legal and strategic process of green transition with the adoption of new strategies and laws, such as the EU Green Deal (EGD, 2019) and the Critical Raw Material Act (European Critical Raw Material Act, 2023) and to finalize the EU Fit for 55 Package (EU Fit for 55, 2023).

The International Energy Agency (IEA) strongly advocated the need for critical minerals in May 2021 by launching a critical mineral security programme to ensure the stability of the supply chain for clean technologies and guarantee the process of green energy transition to combat the impacts of climate change.

According to the World Bank, the demand for critical minerals could surge by 450% by 2050 if clean technologies are employed on the scale required to meet the Paris Agreement goal “to pursue efforts to limit the temperature increase to 1.5C above pre-industrial levels.” To meet this enormous demand, the European Union must strategically and autonomously take prompt action, diversify its energy supply sources, and guarantee access to critical minerals. Such a “European strategic autonomy” is not a question of sovereignty or independence but rather a capacity to live by its

laws, rules, and norms while being prepared to act alone if necessary (Tocci, 2021).

To achieve these programmes and green energy transition goals, not only the European Union but also the world needs to have guarantees about energy supply and sufficiency, and surety in having access to these critical minerals in stable and non-volatile countries.

The challenge is to obtain access to these critical minerals in a sustainable way by reducing waste in the extraction of such critical minerals, minimizing environmental damage, and avoiding the escalation of the erosion of planetary boundaries (Rockström et al., 2009) to meet the urgent, global, and cosmopolitan needs to protect human and planetary wellbeing in the current Anthropocene era.

From a geological perspective, DSM has begun to influence the future resource security landscape and is considered a necessity to secure and legitimize the future of sustainable development and design the global politics of energy security, including the role of technology in energy security (Hallgren and Hansson, 2021).

Technological advancements will be key to this mission, as will the ability of legal and policy-based green energy transition frameworks to adapt swiftly to geopolitical changes. For example, the evolution of the EU legal and policy green energy transition framework is intricately influenced by events such as Russia's invasion of Ukraine, which undeniably accelerated and advanced the new concept of EU strategic autonomy in a positive way (Tocci, 2021).

DSM can be perceived within that context as a possibility that can reduce the risks of running out of energy and assure a constant energy supply by securing a sufficiency and surety of critical minerals, diversifying sources of energy, and reducing reliance on "volatile countries." When discussing energy security, volatile countries are characterized by political instability, democratic deficit, corruption, and lack of transparency with no involvement of civil society (Sovacool, 2011) such as the Middle East, Russia, Nigeria, and Venezuela. Although China is a major global player in the energy market and has been able to diversify and enhance its energy security (World Bank in China, 2023), there is an important democratic deficit and weak involvement of civil society in the energy transition process (Bertelsmann, 2022; BTI China Country Report, 2022).

In terms of energy security, the DSM can also help other countries that are more exposed to the impacts of climate change increase their revenues. The geopolitical component is not the only factor shaping, even accelerating, the norms shaping not only the process of green transition in which DSM is embedded but also the interaction between climate change, technology, and social and cultural factors, which play a role in DSM governance as they can facilitate, aggravate, or delay future pathways, both in terms of regulation, security of access, and the achievement of sustainable environmental protection goals. However, there is limited knowledge of the impact of DSM on the environment, economy, technology, and human coastal communities at the societal level (Koschinsky et al., 2018).

From an economic perspective, it is not certain whether the long-term demand for critical minerals from the DSM is justified; in any case, it will be strongly dependent on technological advancements. This is explained in recent reports arguing that the narrative advanced for the vital need of DSM to achieve a

green transition through clean technology and the need for critical minerals to power batteries for intermittent technologies (wind power, solar photovoltaic panels, and batteries) is false, as these can be met by existing terrestrial sources (EU Commission, 2020; EASAC Report, 2023).

Emerging technological advancements to mine the deep sea in a "sustainable manner" may suggest that the green energy transition can be achieved by both mining the deep sea and "without mining the deep sea."

The DSM poses considerable environmental risks; possible environmental damage could have strong transboundary consequences, the effect of which could spread over hundreds of thousands of kilometers of the ocean, with devastating consequences for fragile and pristine ecosystems of marine fauna and flora and damaging important habitats. Waste discharge also has harmful effects.

There is considerable *uncertainty* regarding the environmental impacts of DSM, and current studies are exploring the risks of DSM stirring up seafloor carbon sediments and the impact of the release of CO₂ escalating on ocean acidification and global warming, which, in turn, calls for a precautionary approach in the regulation, management, and administration of this activity. From a cultural and social perspective, DSM is certainly alleviating the "Not in My Back Yard" syndrome as DSM infrastructure placed in the deep sea does not disturb the landscape and therefore does not pose as many societal non-acceptance reactions, as in the case of offshore wind energy power or other energy infrastructure at sea. However, DSM activities could conflict with environmental assets such as fisheries, shipping lanes, and submarine cables. Yet, there is inconsistent knowledge about the desirability of DSM or how the public perceived this type of activity, except one study that has used interviews and focus groups to explore what the community's reactions would be should exploration go on (Mason et al., 2010).

Should exploration activities occur regulated or unregulated, future pathways in DSM governance have to carefully consider how to balance the protection of environmental and societal benefits and include technological advancements, resource extraction laws, and policies. Moreover, social impacts can occur, such as employment and cultural changes, for example, changes in traditional family or indigenous cultures or in sectorial economies (Koschinsky et al., 2018), and may occur at near and far distances, such as in the Exclusive Economic Zone (EEZ) or in the Area (Durden et al., 2018) or can even be global (Floyd, 2014).

However, the status of knowledge regarding environmental impacts, energy security needs, economic benefits, social impacts, and most importantly, how all these factors can be incorporated into regulatory frameworks remains unknown and represents an enormous uncertainty regarding the future environmental legal governance of DSM.

Although the negative impacts of DSM remain unknown, there is no need to wait to discover them before establishing an effective system of enforcement (Read, 2022).

In any case, these risks and uncertainties lead to the question of whether DSM is ethically acceptable at the global level, which means that existing environmental legal frameworks, which continue to be in the formation phase, coupled with a precautionary approach delaying business progress in the DSM business, would probably be insufficient for justifying exploitation

to begin in the long-term future, as it will simply provide false hopes to the international community in the capacity of regulators to factor uncertainties, knowledge gaps, and risks in the regulatory framework.

4 The position of the ISA

The ISA is an international organization established by Part XI of the UNCLOS with a legal personality mandated to oversee activities in the Area (Article 157 UNCLOS) and deal with DSM. The ISA shall act for the benefit of humankind as a whole, with an important mandate to ensure the effective protection of the marine environment from harmful effects which may arise from activities in the Area (Article 145 UNCLOS). All state parties to the UNCLOS are *ipso facto* members of the ISA. Currently, there are 167 member states and the European Union, representing 27 member states. The United States is neither a party to UNCLOS nor a member of the ISA, although it participated and intervened as an observer in meetings without the right to vote. The principal organs constituting the ISA are the Assembly, Council, and Secretariat [Article 158 (1) UNCLOS]. The Council is the executive organ of the Authority [Article 162 (1) UNCLOS]. A Legal and Technical Commission is composed of a group of independent experts specializing in different subject areas that are important for the exploration of natural resources (such as oceanography, protection of the marine environment, and economic and legal matters related to DSM). Part XI of UNCLOS establishes a Financial Committee composed of member specialists in financial and other aspects of the DSM. There remains much to be done by the ISA on how to evaluate environmental considerations and, most importantly, the capacity of the ISA to apply a precautionary approach. In that sense, the ISA should carefully consider and assess the risks of environmental damage to fulfill its mandate to preserve the marine environment (Article 145 UNCLOS) by adopting appropriate measures, particularly regarding risks and uncertainties in developing an environmental legal framework.

The nature of such measures depends on the likelihood of the seriousness of the risks and, in certain cases, when (a) scientific evidence cannot be assessed conclusively, potentially harmful activities may be temporarily prohibited or delayed (Environmental Justice Foundation, 2023) or, alternatively, (b) a total ban is the only possible response to certain risks (EU Commission, 2020). Two types of precautionary approaches are applicable to DSM activities. Section 6 elaborates on these two types of precautionary approach.

An important event in the DSM concerned negotiations within the ISA that recently occurred in Kingston, Jamaica, in July 2023. These negotiations are significant because they reflect a situation in which the DSM regime is left in a state of uncertainty, incompleteness, or stalemate. Despite such an uncertain legal status, DSM activities will proceed instead of being blocked. The delegates reached a partial compromise. The point of contention was whether to discuss two proposals at the meeting: one to conduct a review of the ISA itself and the other to rule on the DSM (Alberts, 2023). One proposal proposed by Germany called for the assembly to discuss conducting a “periodic review” of the ISA and its procedure every 5 years (as stipulated by UNCLOS); the last review was completed 6 years ago. The other proposal, submitted by Chile, and France referred to the “Two-Years rule” in the

marine environment. Other items focused on financial matters, the granting of observer status to Non-Governmental Organizations (NGOs), and the ISA’s proposal for a strategic plan to provide a road map for how the ISA should work over the next 5 years. The Two-Years rule had already expired on July 9 without the ISA having fully developed the mining rules. China rejected the inclusion of the first two proposed items on its agenda. Finally, the Jamaican negotiations concluded after a total stalemate on these two key agenda elements.

However, whether and when the Two-Year Rule imposing a “hard” deadline may be imposed remains unknown, thereby placing the environmental regime under continuous discussion. At some point, this work in progress will come to an end and activities of exploitation will begin; however, these discussions will probably be the object of debate in the upcoming sessions of the ISA Council in the coming years (Blanchard et al., 2023).

The ISA has the authority to adopt regulations that are automatically binding on all members, and individual states cannot opt out of a rule with which they disagree, a power that makes the ISA different from many other international organizations whose standard-setting power usually depends on the subsequent consent of states or at least allows the options of reservation from member states (Harrison, 2016).

From an international environmental and energy law perspective in dealing with natural resources, the ISA has a unique opportunity to be able to regulate, administer, and manage an activity (DSM exploration and exploitation) that belongs to “humankind.” In that sense, the ISA is the only quasi-regulatory institution that represents “humanity” in exploration and exploitation and sharing of benefits of those resources. Legally, this unique position entails that neither “everyone” nor “anyone” can exploit resources in the Area. All of the “international community” cannot simply make use of it.

For that purpose, the UNCLOS foreshadows the establishment of the “Enterprise” that will conduct DSM activities on behalf of the international community and should represent both humankind and mankind simultaneously offering a perfect example of a future attempt to integrate synergistically and for the first time the concept of common concern of humankind with the principle of common heritage of mankind.

5 The position of the European Union

There was no formal position of the European Union regarding DSM activities but an ambiguous position for a long time. The EU Commission has demonstrated a precautionary approach visible in the recent Biodiversity Strategy (EC, 2020) published in March 2022, according to which marine minerals should not have been exploited until the effects of DSM on the marine environment are not fully understood. However, the EU Commission continues to fund a certain number of projects related to DSM activities, particularly in understanding technological advancements that may lead to “sustainable environmental DSM activities.”

Initially, in 2012, the EU enthusiasm for DSM was visible in the “Blue Growth Opportunities for Marine and Maritime Sustainable Growth” communication released by the EU Commission, and subsequently by major EU funding from DG Mare for the 2014–2020 period and in the number of projects funded by

the European Union, particularly under the framework of EU Horizon 2020 Framework Programmes that supported primarily DSM technology development and, only to a lesser extent, environmental impacts.

Later, in 2020, after the adoption of the precautionary statement of the EU Biodiversity Strategy (EU Biodiversity Strategy of 2020, 2020) and the European Parliament's call for a moratorium, the European Union adopted a much more precautionary approach, considering the environmental risks combined with significant knowledge gaps and the question surrounding the need for DSM in global supply (Report, 2021).

In 2016, a communication titled "International Ocean Governance: An Agenda for the Future of our Oceans" (EU, 2016) acknowledged that "the current framework does not ensure the sustainable management of the oceans," specifically referring to the ISA.

Such communication also established a mandate for the EU Commission to "produce guidance on the exploration and exploitation of natural resources on the seabed in areas under national jurisdiction, to assist coastal member states respecting the duties under UNCLOS to protect and preserve the marine environment by 2018." However, to date, such a mandate has not been achieved, and some EU member states have indicated interest in exploring DSM in European waters. Several European countries hold or sponsor DSM exploration contracts with the ISA (Belgium, Bulgaria, the Czech Republic, Slovakia, Poland, France, Germany, and the United Kingdom). Other European countries such as Italy, Norway, Portugal, Spain, and the Netherlands have also signaled potential interest in pushing DSM on their continental shelves or companies that are significantly involved in technological developments (such as Italy, Norway, Portugal, Spain, and the Netherlands). For example, it is noteworthy that Portugal has signed a moratorium. However, the involvement of companies of a given country does not mean that it is the country's position or, even less, the position of the European Union or member states.

The European Union is a party of UNCLOS and has voting rights at the ISA assembly but has always been present as an observer at the Council. The European Union has been cautious about expressing its formal position for decades as a member of the ISA, with no mandate to assume an EU position on behalf of member states.

The only proposal issued by the European Union was in January 2021, with the proposal for a "Council Decision on the Position to be Taken on behalf of the European Union at the Meetings of the ISA Council and Assembly" (EC, 2021). In Annex I of the mentioned Council Decision, it is stated that "the EU should advocate that marine minerals in the International seabed area cannot be exploited before the effects of deep-sea mining on the marine environment, biodiversity and human activities have been sufficiently researched, the risks are understood and the technologies and operational practices are able to demonstrate a serious harm to the environment, in line with the Precautionary principle."

This stance aligns with the current position of the European Union, reflecting the collective actions of the European Commission, European Parliament, and various member states in endorsing a moratorium until the ecological consequences can be

comprehensively understood, measured, and controlled (EASAC Report, 2023).

Currently, the European Union appears to embrace strongly also the line that supports the nexus of climate, biodiversity, and mining in the EU Biodiversity Strategy of 2020 and the strategy of the EU Green Deal based on the "no harm" principle aiming to be a leader in protecting oceans and seas at the global level. The EU Biodiversity Strategy of 2020 is based on Article 191 of the Treaty on the Functioning of the European Union stating that EU policy must be based on precautionary principles.

It is noteworthy that an EU panel of top experts of the European Science Advisory Council (EASAC Report, 2023) released a report stating skepticism about the need to mine the deep sea to secure energy supplies because DSM would not be able to provide many of these critical mineral needs to build clean energy technologies that would enable the green energy transition (EASAC Report, 2023).

6 DSM and the precautionary approach: only one type of approach?

Proponents of delayed approaches could delay the adoption of essential measures to ward off irreversible damages in the absence of incontrovertible proof, which means that proponents of a delayed approach may conclude there is no impact when there is one, thus resulting in "false-negative errors." There are two chief schools of thought on precautionary approaches that distinguish between the (1) business-as-usual precautionary approach and the (2) anticipatory precautionary model approach (de Sadeleer, 2022).

A precautionary business-as-usual approach delays actions until experts are able to provide strong evidence establishing that there is an acceptable or unacceptable biological impact on the environment and would lead to false-negative errors because there would be blind faith in science, and it would not be absolutely necessary to eliminate unacceptable biological impact and pollution until the moment that the opposite is proved (i.e., the level of pollution is unacceptable). A precautionary anticipatory model approach is based on mitigating impacts irrespective of full scientific certainty and may lead to "false-positive errors" (setting the exact level of permissible pollution or "acceptable biological damage" according to an established threshold and a risk assessment analysis) aiming at mitigating efforts early rather than waiting decades and taking actions *ex post*, after the problem has occurred and advanced.

In Table 1 (de Sadeleer, 2022), the differences between the two precautionary approaches are clarified.

These two schools of thought can be applied to DSM. According to the Draft Regulations on Exploitation of Mineral Resources in the Area, if it is to fulfill its mandate, the ISA must draw on the best available science to assess the potential impacts of DSM and make informed decisions based on sound scientific evidence to ensure that mining does not cause serious harm to the marine environment.⁹

To fulfill its mandate, the ISA must draw on the best available science. Moreover, when exercising its power under UNCLOS,

⁹ Draft Regulation on Exploitation of Mineral Resources in the Area, Regulation 2 (g), and Schedule.

TABLE 1 Differences between two precautionary approaches (de Sadeleer, 2022, op. cit.) applied to Deep Seabed Mining (Cassotta and Goodsite, 2024).

Approach	Business-as-usual model approach	Anticipatory model approach
Advantages and disadvantages	A pre-emptive approach would sacrifice economic welfare	A pre-emptive approach would avoid the occurrence of irreversible damage
Investment in research	Should reduce the risk associated with premature and costly measures	Should reduce the level of uncertainty to foster optimal strategies
Paradigm	Sound science paradigm: delay actions until experts can provide convincing evidence	Precautionary paradigm: mitigate impacts irrespective of full scientific certainty
	Learn and then act	Better safe than sorry
Errors	False-negative errors	False-positive errors

the ISA is obligated to apply a precautionary approach (Advisory Opinion, 2011).

As noted in Section 2, the precautionary principle is not explicitly mentioned in UNCLOS provisions. However, according to international customary law, treaty provisions must be interpreted in their context (Vienna Convention on the Law of Treaties, 1969).

However, there is no specific incorporation of the precautionary principle in ISA regulations but more of a precautionary approach, considering that the ISA is obligated to take preventive measures to safeguard the marine environment where there are “plausible indications of potential risks, despite insufficient evidence to fully predict the extent and magnitude of the potential negative impacts” (La Porta, 2021).

Reference can be made here to the precautionary approach in Regulation 31 (2) of the Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area, (ISBA/19/C/WP.1), which states:

“2. In order to ensure effective protection for the marine environment from harmful effects which may arise from activities in the Area, the Authority and sponsoring States shall apply a precautionary approach, as reflected in principle 15 of the Rio Declaration, and best environmental practices. 3. The Legal and Technical Commission shall make recommendations to the Council on the implementation of paragraphs 1 and 2 above.”

As seen in the previous section, although substantial scientific evidence has already established a clear risk of serious harm to the marine environment, the precise extent and magnitude of the environmental damage that is likely to be caused, potentially on a global scale, remains unknown, particularly in marine ecosystems. This means that when scientific evidence cannot be assessed, potentially harmful activities may be temporarily prohibited. It is noteworthy that for the DSM industry, scientific evidence can only be obtained if activities are not prohibited. It is the execution of activities such as test mining, exploration campaigns, and, to a certain extent, exploration that allows the scientific community to gather all evidence, analyse data, and publish conclusions.

Thus, the ISA is responsible for developing a set of regulations that govern future exploitation, incorporating the precautionary approach in the EAM. However, some vagueness applies to the ISA in its current Draft on Exploitation Regulations, where the ISA commits to implementing EAM as one of its governance principles simultaneously as it does not expressly recognize EAM as the best

management practice to cope with the environmental effects of DSM. Elements of the EAM can also be found in the Mining Code and REMPS of the Clarion–Clipperton Zone; however, no practical measures have been taken by the ISA in that sense (Christiansen et al., 2022).

Therefore, EAM is linked to the precautionary approach, as it is a set of comprehensive, cross-sectoral approaches that implement the precautionary approach through a long-term vision, strategic goals, and management strategies and acts on best environmental practices or best available practices (BAPs) and best available technologies (BATs), where scientific data and technological knowledge represent the fulcrum of its action while acknowledging the existence of uncertainties.

Therefore, the type of precautionary approach selected by the ISA corresponds to the business-as-usual precautionary approach rather than the anticipatory model approach, which means that the ISA approach is clearly based on a “delayed approach.”

The Mining Code contains important protective measures which have not yet been implemented. Furthermore, the Legal and Technical Commission has not yet deliberated the impact of mineral exploitation on vulnerable ecosystems, such as remote waters (e.g., the Arctic) and hydrothermal vent communities.

The Mining Code allows far-reaching measures to be adopted, including the possibility that these activities¹⁰ are not authorized to proceed if they are found to be seriously harmful. Instead of acting on these provisions, the ISA has continued to grant exploration contracts to areas around vulnerable ecosystems without assessing their potential impacts. This is potentially disastrous because scientific discussions regarding the restoration phase demonstrate that post-mining restoration is impossible in some cases and certainly costly in others.

Although the DSM is currently in the exploration phase, the implementation of precautionary measures will be vital during the next exploitation phase. After conducting an analysis of the strengths and weaknesses of ISA work during the exploration phase, it has been established that ISA has difficulties in implementing a precautionary approach in the exploration phase, specifically in applying protective measures at an earlier stage, acting in a timely manner with respect to designation and impacts and preservation reference zones, and protecting particularly vulnerable ecosystems, such as the setting of areas of particular environmental interest, such as the Clarion–Clipperton

¹⁰ Nodules, Sulphides, and Crust's Exploration [Regulation 33 (4)].

Zone (Jaeckel, 2017). Strategic vision for balancing DSM business activities and environmental protection is sadly lacking and demonstrates a blind reliance on the school of science that is in accordance with the business-as-usual model precautionary approach, which supposes a secondary role for the ISA.

The application of the precautionary approach by the ISA is weak, although it plays a vital role in science. Currently, several challenges remain, such as the establishment of a procedural framework that enables risk assessment and management, timely measures, and the capacity of the ISA to factor science into the legal environmental liability framework, which is aggravated by a lack of scientific data.

The precautionary approach alone is insufficient, and there is a clear need for a holistic, regulatory framework vision that would integrate re-redesigned environmental liability rules and compensation mechanisms with the precautionary approach to EIAs, EAM, and REMP's with the purpose of finding a balance between DSM activities and environmental protection. However, to avoid false-negative errors, avoid the occurrence of irreversible damage, and mitigate impacts irrespective of full scientific certainty, the anticipatory model approach instead of an anticipatory business-as-usual model approach is desirable to develop an environmental regime framework, and exploitation should become not only a reality in the future but also be fair and equitable.

7 Technological advancements and Article 31 of the Vienna Convention on the Law of Treaties requirements

Article 31 of the Vienna Convention on the Law of Treaties provides a general rule for interpreting treaties (Vienna Convention on the Law of Treaties, 1969). It states that “a treaty shall be interpreted in good faith in accordance with the ordinary meaning to be given to the terms in the treaty, in their context and in light of its object and purpose” (Article 31, Section 3, General Rules of Interpretation, Vienna Convention on the Law of Treaties, 1969).

DSM activities are typically governed by a specific treaty called UNCLOS. While separating a treaty from the Vienna Convention on the Law of Treaties, the UNCLOS is subject to the principles of Treaty Interpretation outlined by the 1969 Vienna Convention, including Article 31. According to the latter article, in the context of DSM, technological advancements must operate in four legal environments to meet the following requirements: (1) good faith, (2) ordinary meaning, (3) context, and (4) objective. However, although there is an understanding of what BATs and BAPs would be for DSM, the robustness of the data is hindered by the lack of practice and a baseline yet to be established by regulation.

The application of Article 31 to DSM depends on the specific treaties involved. For instance, if a treaty was established specifically to regulate DSM activities and technologies, Article 31 would guide the interpretation and application of that treaty. Although the ISA has been developing a regulatory approach since its inception and there are active and relevant research efforts, there are as of yet uncommon technological advancements that routinely meet Article 31 requirements, or regional requirements such as those

that would be required in operating in European waters where the European Regulation for Registration, Evaluation, Authorisation, and Restriction of Chemicals (REACH regulation) Regulation (EC) No. 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation, and Restriction of Chemicals—REACH and the precautionary principle would apply.¹¹

The sector develops technologies and conducts studies to minimize the environmental impact once the ISA or relevant regulatory body for the waters where extraction is to occur approves the operation. Although much can be modeled and inferred from the first operations and other lessons learned from deep-sea extraction operations, much of the learning will only be validated from operational experience. Learning will only be available once the mining process begins in earnest, with data collected uniformly across operations and independently assessed. Thereafter, technological advancements will be truly tested as to whether they meet the Article 31 requirements. In conclusion, the current technological advancements are far behind meeting Article 31.

8 DSM in a justice and ethical dimension

Environmental justice and ethics should consider collective action problems affecting the Area in the same way as other phenomena, such as global warming or ocean acidification. Future impacts on the area will be caused by human hands acting on individuals, businesses, or states. If the Area is damaged environmentally, the damage will reverberate at a planetary level, as the Area has crucial importance for both the health of the planet and all humanity. Therefore, it is important that harvested resources be utilized in a sustainable manner, considering the needs of future generations (Baslar, 1999).

A key question is whether mining activities would be of common interests of humankind as whole as required under UNCLOS, bearing in mind that UNCLOS does not allow any trade-offs between the imperative of environmental protection and of the future of the common heritage of mankind. The issues at stake are of far-reaching global significance, with implications for people's wellbeing and, potentially, their survival. However, simultaneously, it can be argued that the demand for mineral resources is equally vital for human survival in the face of climate change impacts and the geopolitical era of green energy transition. However, the potential of the DSM has not yet been rigorously quantified. Owing to the lack of social legitimacy (Jaeckel et al., 2023), the necessity of DSM is questionable.

¹¹ Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC, and 2000/21/EC (Text with EEA relevance).

Before initiating the process of revising ISA regulations, it may have been prudent to investigate or conduct a survey to determine the level of support from civil society (stakeholders, NGOs, groups of interest, scientists, or indigenous, and local communities) regarding the acceptance of DSM activities.

Several important reactions against DSM came from UN organizations, NGOs, other stakeholders, scientists, seafood groups, and indigenous people. For example, the UN High Commissioner for Human Rights urged ISA delegates to issue a moratorium on DSM, warning of the potential for irreversible damage to marine ecosystems and the climate. This is the first time that a UN representative has criticized DSM in a public forum (Alberts, 2023a,b). Many NGOs have reacted against DSM, such as the Deep-Sea Conservation Coalition or Greenpeace, the World Wildlife Fund, the European Academies Science Advisory Council advocating skepticism (EASAC Report, 2023), and the EU Commission, which confirmed the same position in a study (EU Commission Critical Raw Material for Strategic Technologies and Sectors in the EU, 2020). Moreover, indigenous activists have recently made clear that they do not provide their consent to DSM in a petition at the ISA, where over 1,000 signatures from 34 countries and 56 indigenous groups called for a total ban on DSM (Brooks, 2023).

The decision-making process and actors involved are uncertain factors in the game. Although the ISA has the legal competence to permit DSM under the UNCLOS, concerns arise about whether the ISA's current decision-making procedures align and "do justice" with its mandate to "act on behalf of all humankind."

UNCLOS calls for the equitable sharing of economic and other financial benefits of mining on a non-discriminatory basis through appropriate mechanisms [UNCLOS, Article 140 (2)] with concepts such as non-appropriation, benefit sharing of economic and financial benefits, and the preservation of future generations.

The principle of common heritage of mankind is enshrined in the Mining Code—in both the ISA Exploration Regulations and the Draft Exploitation Regulations currently under development. Such a draft requires the ISA, when determining whether to approve an application for an exploitation contract, to consider how the proposed plan of work contributes to realizing benefits for humankind as a whole.¹²

The key question is whether, among the benefits of *humankind as a whole*, the need for critical minerals to achieve a green energy transition is vital for the survival of mankind in the Anthropocene Era.

The IEA projections indicate that to achieve a green transition, we will need as much as four times the minerals we have today (IEA, 2022).

In the Anthropocene era, it has not been established whether the use of minerals is instrumental in the struggle against the impacts of climate change, or if it is a false narrative owing to the potential risks of DSM activities, which are not yet known, as reported by the Intergovernmental Panel on Climate Change

(IPCC) and the latest Report on Oceans and Cryosphere in a Changing Climate of 2019 (IPCC, 2019). Neither report has been able to highlight the potential vulnerabilities and risks in the area, as research is absent on the deep ocean (waters below 200 m; Levin, 2021).

To avoid a future tragedy of the commons, it is vital to upgrade the design of the environmental law regime, including issues of environmental liability standards regarding potential activities of exploration and exploitation that would be permitted, with deteriorating consequences for the benefit of all, to design a future cosmopolitan environmental regime in accordance with cosmopolitan law. Cosmopolitan law (Cassotta, 2021) is based on the need to protect the rights and dignity of all individuals (Kant, 1975). New standards of liability should be connected to the environmental justice criteria. They should include a stronger environmental damage regime, a stronger environmental liability regime by establishing a clear notion of environmental damage, a threshold for when it can be considered damage acceptable or not acceptable, a clarification regarding the hazardous categorization of DSM activities which is currently absent but needed as there is a need to understand if DSM activities are classified as "hazardous." These key legal environmental focal points of the environmental regime should be interconnected with critical and justice environmental theories: (1) contribution to the problem: a corrective approach, (2) ability-to-pay principle: a distributive justice, and (3) a hybrid approach: a corrective and distributive approach leading to legal cosmopolitanism. The first approach, a corrective approach, focuses on who is responsible for environmental damage by linking the polluter-pays principle to environmental liability to solve enigmas and *uncertainties* and is based on the idea that it is the countries that primarily cause pollution that should pay, including past historical pollution they created. The second approach, distributive justice, focuses on who has the capacity to pay for and mitigate (in terms of income distribution). The third approach is a hybrid approach that integrates corrective and distributive approaches as a cosmopolitan justice view, in that it is a global response rather than a state-based response. The heritage of cosmopolitan justice is debated considering these pressing concerns including inequalities, rapid loss of biodiversity, and unmitigated impacts, such as those in the Arctic case (Skillington, 2017).

The idea could be that preventing and moderating the negative consequences of DSM suggests that someone should take responsibility for limiting the actions of actors that increase common risks. For example, this could be done by transferring the risks of environmental damage to DSM to all actors involved in DSM activities by establishing an environmental DSM Fund of Compensation, as already envisaged,¹³ and as has been done in the past to clean up and compensate victims of several hazardous activities (oil spills, toxic chemicals, and asbestos contaminants). In this way, the environmental regimes of DSM would be reinforced, as new standards of environmental liability for DSM activities would minimize *uncertainty* regarding the future cosmopolitan benefit of all.

¹² Draft Regulation on Exploitation of Mineral Resources in the Area, Regulation 12 (3).

¹³ Draft Regulation on exploitation of minerals resources in the Area, ISBA/25/C/WP.1, Regulation 54.

9 Geopolitical-legal aspects of DSM and green technologies in the Arctic: the case of the United States, Norway, Svalbard, and China

The Arctic Circle has become an important symbol of the devastating impact of climate change, however, its role as a central focus site for geopolitical conflict deserves equal attention. “*As the Arctic’s treacherous polar ice caps melt away, nations have begun to engage in a modern gold rush over the region’s unclaimed territory, natural resources, and strategic position*” (Gross, 2020). Beyond economic motivations, nations such as the United States, Russia, and China compete in the region to project military supremacy and seek more power (Murdoch, 2023; Wachtmeister, 2023). They can mine heavy equipment from the ice and then sail the extractives to many destinations from northern shipping routes once the ice breaks up (Korkut and Fowler, 2019). The geopolitical-legal aspects of seabed mining and green technologies are complex and multifaceted, even before considering the additional legal and geopolitical complexity and dynamics in the Arctic (Trainer, 2022).

UNCLOS mandates that states govern DSM within their national jurisdiction (Trainer, 2022). However, 60% of the ocean bed is located beyond the jurisdiction of the individual states. In these waters, the DSM is regulated by UNCLOS which created the ISA. As mentioned in Section 2, some States, including world powers, have differing, competing, or incompatible interpretations of UNCLOS and domestic maritime laws. For example, Russian experts often state that Russia does not recognize the applicability to the Arctic of the principle-of-common-heritage-of-mankind regime provided by UNCLOS (Tordov, 2019) in relation to the seabed area beyond the continental shelf. In that sense, Russia’s standing point would thus be opposite to the standing point of several politicians and legal experts who have expressed the possibility for the Arctic Ocean to follow the example of the Antarctic legal regime considering a convergence of the Antarctic mining and global atmospheric issues of greenhouse and ozone varieties as under this scenario, the global atmosphere and Antarctica would be “common property resources,” “global commons” (Herber, 1991), or a common concern of humankind. In addition, as previously explained (Section 2.1) it is not excluded that both the concept of common concerns of humankind and the principle of common heritage of mankind applies in the case of the Arctic Ocean exploitation (Dervovic, 2021) considering the magnitude of global impacts from the Arctic to the rest of the planet.

In the United States, Norway, Svalbard, and China, several factors are at play. China currently holds 5 of the 30 DSM contracts issued by the ISA—more than any other country (Trainer, 2022). This dominance in DSM has led to concerns about China’s influence over the regulatory environment (Soderberg, 2023).

In contrast, Norway has adopted a more cautious approach to DSM. The Norwegian government has stated that it will not allow DSM until the environmental risks are better understood (Trainer, 2022). Svalbard is a unique case, as it is an archipelago located in the Arctic Ocean and subject to the (Svalbard Treaty, 1920). This last treaty not only grants Norway sovereignty over Svalbard but also provides for equal rights

to engage in commercial activities on the archipelago for all signatory countries.

This has led to tensions between Norway and other signatory countries, including Russia and China, over access to resources in Svalbard’s waters (Alberts, 2023). Potential exploration in the Arctic area may result in environmentally harmful effects on fauna and ecosystem services (Ramirez-Llodra, 2020), which is why the use of different technologies will be crucial for implementing a precautionary anticipatory approach to manage and regulate environmental law.

Although the geology under the Arctic Ocean may not be as predictive of attractive subsurface resources as the areas in the Pacific Ocean, if abundant minerals are found terrestrially, they may be found in the seabed of the Arctic floor and therefore be attractive for extraction. This could undoubtedly lead to even greater tensions considering the intersection of Arctic shipping lanes with Russian and Chinese geopolitical ambitions (Greenwood and Luo, 2022).

Therefore, when discussing DSM in the Arctic, a novel approach in which the Arctic states re-examine the Westphalia conception of sovereignty in favor of a cosmopolitan law approach, which means promoting not only rights of states but also universal entitlements or duties to the benefit of all and serving both a common concern of humankind and a common heritage of mankind and global justice intergenerational arguments, is required.

10 Discussion and conclusion

Although the literature and policies are forthcoming, there is no DSM legal framework with international acceptance that is just and sustainable. There is a lack of laws that ensure proper environmental assessment and impact management at the cost of providing the materials required to electrify society. The precautionary approach in the current DSM legal framework is insufficiently informed and incorporates the necessary level of technological advancement that would permit the activity to be conducted in a sustainable and environmentally friendly manner.

Technological advances and knowledge are becoming so relevant that they shape the environmental regime of DSM activities because they can improve monitoring and reporting.

The level of technological advancement can also enhance environmental compliance (by reducing the frequency of environmental harm), provide a better understanding of how to define environmental harm and the threshold, establish the extent of pollution, determine the maximum level of assimilative capacities of harmful substances, and make EIAs more effective. Intelligent, precautionary, independent, and accelerated research is lacking to better understand what is at stake and how to maximize opportunities without compromising sensitive ecosystems for the sake of our planet. There is an urgent need to understand the type of precautionary approach that best fits DSM activities in the current process of green energy transition.

This study identified two types of precautionary approaches applicable to DSM: the precautionary business-as-usual model

approach and the anticipatory model approach. An anticipatory model approach is desirable for developing an environmental legal framework. However, as the precautionary model approach alone is insufficiently effective, it would be prudent to design a patchwork of combined instruments (hard and soft laws) with the ultimate purpose of designing a new legal framework capable of applying a precautionary approach based on the anticipatory model approach. Such an integrative flexible regulatory patchwork will require the environmental regime of the DSM to adapt to scientific and technological developments. This precautionary approach is also relevant to the future deployment of new technologies with security implications. Several challenges remain to be solved, such as risk factors and uncertainties, in a just and sustainable systematic way to the benefit of all with a cosmopolitan law and justice able to embed the new green energy transition context and geopolitical dimension. Risk assessment and management are not yet incorporated into ISA regulations and the “science factor” based on what is the acceptable or unacceptable level of impact in the biological system by establishing a threshold and conducting a risk assessment analysis in combination with other important components such as technological knowledge, justice, and fairness are not yet factored in the environmental legal framework of DSM.

ISA's activities can represent a holistic *laboratorium* where the need to carefully balance legally common property, common concern of humankind, and common heritage of mankind within the context of green energy transition, and under an ethical, justice, global, and cosmopolitan acceptance, and technological advancements will be vital for human planetary Earth survival.

Author contributions

SC: Writing – review & editing. MG: Writing – review & editing.

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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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