USING INTERNATIONAL LAW TO PROTECT MARINE BIODIVERSITY FROM DEEP-SEA MINING

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"The dark oceans were the womb of life: from the protecting oceans life emerged. We still bear in our bodies—in our blood, in the salty bitterness of our tears—the marks of this remote past. Retracing the past, man, the present dominator of the emerged earth, is now returning to the ocean depths. His penetration of the deep could mark the beginning of the end for man, and indeed for life as we know it on this earth: it could also be a unique opportunity to lay solid foundations for a peaceful and increasingly prosperous future for all peoples."
Maltese Ambassador Arvid Pardo, 1967 speech to the U.N. General Assembly

Deep-sea mining, the extraction of minerals from the seabed, is likely to have major environmental impacts. Studies point to possible impairment of key ecosystem functions through pollution and biodiversity loss. Notwithstanding the inability to predict the full extent of spatiotemporal

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environmental impacts, negotiations are underway at the International Seabed Authority to finalize regulations for commercial extraction of critical minerals in the international seabed. The regulations under negotiation would permit deep-sea mining to proceed despite significant scientific uncertainty; however, international law prohibits deep-sea mining unless science demonstrates that it can be conducted while adequately protecting biodiversity and preserving ocean health. Consequently, we argue that, to comply with international law, a moratorium on deep-sea mining is required until a greater understanding of its environmental impacts is reached.

INTRODUCTION

The world is currently experiencing a biodiversity crisis driven by anthropogenic activity.[1] Ecological systems are dysregulated and

[1] *See* Robert H. Cowie, Philippe Bouchet, & Benoît Fontaine, *The Sixth Mass Extinction: Fact, Fiction or Speculation?*, 97 BIOLOGICAL REVIEWS 640 (2022); Lily Linke & Christopher F. Clements, *A Sixth Mass Extinction? How Linguistic Uncertainty Shapes Our Understanding of the Biodiversity Crisis*, 14 ECOLOGY & EVOLUTION (2024), https://doi.org/10.1002/ece3.70653. Whether global

have reached or exceeded climate tipping points, with serious impacts for the global climate system and life on Earth.[2] Marine ecosystems—which support the majority of animal biomass, absorb carbon and other gases, and produce oxygen—are depleted and under intense stress.[3] Effective marine management must include biodiversity protections.[4] Biodiversity loss has serious consequences for ecosystem health and can lead to ecosystem collapse.[5] In this context of global crisis, extractive marine industries would put additional pressure on marine ecosystems through habitat destruction, biodiversity loss, and pollution. Currently, States are negotiating regulations that would permit large-scale commercial deep-sea mining in the international seabed, a zone known as "the Area," which would compound existing stresses on marine ecological systems.[6]

Deep-sea mining involves extracting minerals by removing material from the surface or subsurface of the seafloor.[7] Proponents

biodiversity is experiencing a sixth mass extinction is contested but there is clear evidence that Earth is experiencing a biodiversity crisis.

[2] Intergovernmental Panel on Climate Change, *Climate Change 2023: Synthesis Report*, (2023), https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_FullVolume.pdf [https://perma.cc/P53W-6Z55] [hereinafter IPCC].

[3] *See* United Nations, *The Second World Ocean Assessment* (2021), https://www.un.org/regularprocess/woa2launch [https://perma.cc/4AP6-YHEQ]; Mark John Costello, Marta Coll, Roberto Danovaro, Pat Halpin, Henn Ojaveer, and Patricia Miloslavich, *A Census of Marine Biodiversity Knowledge, Resources, and Future Challenges*, PLOS ONE 5(8) (2010).

[4] *See generally* Cowie et al., *supra* note 1 (noting that marine biomass reduction is well-documented and discussing the human role in driving extinction); Boris Worm, Edward B. Barbier, Nicola Beaumont, J. Emmett Duffy, Carl Folke, Benjamin S. Halpern, Jeremy B.C. Jackson, Heike K. Lotze, Fiorenza Micheli, Stephen R. Palumbi, Enric Sala, Kimberly A. Selkoe, John J. Stachowicz & Reg Watson, *Impacts of Biodiversity Loss on Ocean Ecosystem Services*, 314 SCI. 787 (2006) (demonstrating that sustainable management measures can reverse biodiversity declines).

[5] Worm et al., *supra* note 4, at 788–789.

[6] Holly J. Niner, Jeff A. Ardron, Elva G. Escobar, Matthew Gianni, Aline Jaeckel, Daniel O. B. Jones, Lisa A. Levin, Craig R. Smith, Torsten Thiele, Phillip J. Turner, Cindy L. Van Dover, Les Watling, Kristina M. Gjerde, *Deep-sea Mining With No Net Loss of Biodiversity—An Impossible Aim*, 5 FRONTIERS MARINE SCI. 1 (2018).

[7] *See* Daniel O.B. Jones, Diva J. Amon, & Abbie S.A. Chapman, *Deep-Sea Mining: Processes and Impacts*, in NATURAL CAPITAL AND EXPLORATION OF THE

argue that the growing demand for critical minerals used in renewable energy and other technologies could be fed by minerals from the deep-sea, helping the critical transition away from fossil fuels.[8] Moreover they assert that deep-sea mining will result in fewer environmental and ethical impacts than terrestrial mining.[9] Critics contend that deep-sea mining is unlikely to replace terrestrial mining—occurring instead alongside terrestrial mining—and that experts still do not know enough about deep-sea mining's ecological, economic, and social impacts to effectively regulate or even to permit the activity.[10] Motivated variously by concerns over competition with terrestrial mining, mineral market disruptions, and environmental and

DEEP OCEAN 91, 94, 98–99 (Maria Baker, Eva Ramirez-Llodra, & Paul Tyler eds. 2020).

[8] *See generally* James R. Hein, Andrea Koschinsky & Thomas Kuhn, *Deep-Ocean Polymetallic Nodules as a Resource for Critical Materials*, 1 NATURE REVS. EARTH & ENV'T 158 (2020) (a meta-analysis suggesting that deep-sea mining "may avoid some of the environmental impacts of terrestrial mining"); DAINA PAULIKAS, DR. STEVEN KATONA, ERIKA ILVES, DR. GREG STONE, & ANTHONY O'SULLIVAN, WHERE SHOULD METALS FOR THE GREEN TRANSITION COME FROM? (2020) (arguing that deep-sea mining of nodules may have few ecological and social impacts than land-based mining but acknowledging uncertainties in understanding the full impacts of deep-sea mining); *See also* 2022 *Final List of Critical Minerals*, 87 Fed. Reg. 10381 (Feb. 24, 2022) (a list of minerals designated by the United States as critical to national security and development).

[9] *See* Paulikas et al., *supra* note 8.

[10] *See* Verena Tunnicliffe, Luis E. Sánchez, Gavin M. Mudd, Diva J. Amon, Lisa A. Levin, Hannah Lily, Eva Ramirez-Llodra, & Adam T. Cross, *Metal Mining on Land Versus the Ocean in the Context of the Current Biodiversity Crisis*, 4 NPJ OCEAN SUSTAINABILITY, 2025, at 1, 1 (pointing out that deep-sea mining might not replace terrestrial mining); Éléonore Lèbre, Anthony Kung, Ekaterina Savinova, & Rick K. Valenta, *Mining on Land or in the Deep Sea? Overlooked Considerations of a Reshuffling in the Supply Source Mix*, RESOURCES, CONSERVATION & RECYCLING 191 (2023) (discussing rationales for mining and not mining the deep-sea); Pradeep Singh & Aline Jaeckel, *Undermining by Mining? Deep Seabed Mining in Light of International Marine Environmental Law*, 118 AJIL UNBOUND 72, 73, 76 (2024) (pointing out that deep-sea mining may contravene environmental and human rights law); John H. Knox (Special Rapporteur), *Report of the Special Rapporteur on the Issue of Human Rights Obligations Relating to the Enjoyment of a Safe, Clean, Healthy and Sustainable Environment,* 46, UN Doc. A/HRC/37/59 (Jan. 24, 2018), https://digitallibrary.un.org/record/1474985?ln=en&v=pdf, [https://perma.cc/WE2J-H3UK].

ethical concerns, as of early 2026, forty countries have called for a moratorium on deep-sea mining.[11]

Researchers expect the extent of harm from deep-sea mining to be large compared with the scale of deep-sea ecosystems for which biotic features vary over small spatial scales.[12] Additionally, affected ecosystems will recover slowly, because the mineral deposits that constitute the abiotic substrate take millions of years to form and deep-sea ecosystem processes are slow.[13] Potential severe ecological impacts would destabilize and contaminate marine ecosystems, magnify ecological stressors, reduce biodiversity, and hinder sustainable marine management.[14] Contemporary research indicates

[11] *See Momentum for a Moratorium*, DEEP SEA CONSERVATION COAL., https://deep-sea-conservation.org/solutions/no-deep-sea-mining/momentum-for-a-moratorium/ [https://perma.cc/QP9Z-5AJJ] (last visited Oct. 28, 2025); Lèbre et al., *supra* note 10 (discussing impacts from deep-sea mining on terrestrial mining).

[12] Craig R. Smith, Verena Tunnicliffe, Ana Colaço, Jeffrey C. Drazen, Sabine Gollner, Lisa A. Levin, Nelia C. Mestre, Anna Metaxas, Tina N. Molodtsova, Telmo Morato, Andrew K. Sweetman, Travis Washburn, & Diva J. Amon*, Deep-Sea Misconceptions Cause Underestimation of Seabed-Mining Impacts*, TRENDS IN ECOLOGY & EVOLUTION 35 (2020) (explaining that deep-sea ecosystems' biotic features can change over small spatial scales and these biotic features can be unique to the small spatial area where they are found).

[13] *See* Niner et al., *supra* note 6 (explaining that deep-sea mining without severe biodiversity loss is impossible due to the severe ecological impacts and long ecosystem recovery times); Sabine Gollner, Stefanie Kaiser, Lena Menzel, Daniel O.B. Jones, Alastair Brown, Nelia C. Mestre, Dick van Oevelen, Lenaick Menot, Ana Colaço, Miquel Canals, Daphne Cuvelier, Jennifer M. Durden, Andrey Gebruk, Great A. Egho, Matthias Haeckel, Yann Marcon, Lisa Mevenkamp, Telmo Morato, Christopher K. Pham, Autun Purser, Anna Sanchez-Vidal, Ann Vanreusel, Annemiek Vink, Pedro Martinez Arbizu, *Resilience of Benthic Deep-Sea Fauna to Mining Activities*, 129 Marine Environmental Research 76 (2017); Ann Vanreusel et al., *Threatened by Mining, Polymetallic Nodules are Required to Preserve Abyssal Epifauna*, 6 SCI. REPS., 2016, at 3, 5; Tunnicliffe, *supra* note 10; Daniel O.B. Jones, Stefanie Kaiser, Andrew K. Sweetman, Craig R. Smith, Lenaick Menot, Annemiek Vink, Dwight Trueblood, Jens Greinert, David S. M. Billett, Pedro Martinez Arbizu, Teresa Radziejewska, Ravail Singh, Baban Ingole, Tanja Stratmann, Erik Simon-Lledó, Jennifer M. Durden, Malcolm R. Clark, *Biological Responses to Disturbance from Simulated Deep-Sea Polymetallic Nodule Mining*, 12 PLOS ONE 1 (2017), https://doi.org/10.1371/journal.pone.0171750 [https://perma.cc/PA2V-SCUR].

[14] Niner et al., *supra* note 6; Singh & Jaeckel, *supra* note 10, at 76 (pointing out that deep-sea mining may be incompatible with international environmental law and goals). We have chosen to use the term "sustainable marine management" to refer to marine management that employs the concept of "ecosystem-based

that local impacts on fauna and ecosystems around the deep-sea mining area will be severe; however, the spatiotemporal extent of environmental impacts—including cascading impacts on other ecosystems and ecosystem services such as nutrient cycling, food production, and climate regulation—is less well understood.[15] It does not appear possible to mine the seafloor without significant environmental damage.[16]

Overexploitation of the global commons has become an increasingly pressing issue as demand for resources grows and

management" or related concepts as discussed in this footnote. As pointed out by Joji Morishita in a 2008 article, the definition of the term "ecosystem approach" is not always agreed on in international law, nor by experts and practitioners, but we are using the definition used by Sardá et al. that states that ecosystem-based management, which puts the ecosystem approach into practice, "requires consideration of whole ecosystems at a scale that ensures that ecosystem integrity is maintained. It recognizes the complex interactions between species that make up marine ecosystems and so is underpinned by principles of community biology and ecology." Further we would like to clarify that the "ecosystem approach," "ecosystem-based management," and "ecosystem-based fisheries management" all refer to the same concept of ecosystem-centric management that includes humans as part of the ecological system. Joji Morishita, *What is the Ecosystem Approach for Fisheries Management?*, 32 MARINE POL'Y 19 (2008); Rafael Sardá, Susana Requena, Carlos Domingues-Carrió, & Josep Maria Gili, *Ecosystem-Based Management for Marine Protected Areas: A Systematic Approach*, in MANAGEMENT OF MARINE PROTECTED AREAS: A NETWORK PERSPECTIVE 145, 151 (Paul D. Gorlup ed., 2017).

[15] *See generally* Smith et al., *supra* note 12 (discussing gaps in scientific knowledge about the deep-sea which complicate estimations of deep-sea mining impacts); A. R. Thurber, A. K. Sweetman, B. E. Narayanaswamy, D. O. B. Jones, J. Ingels, and R. L. Hansman, *Ecosystem Function and Services Provided by the Deep Sea*, 11 BIOGEOSCIENCES (2014) (discussing deep-sea ecosystem services).

[16] *See* Niner et al., *supra* note 6 (explaining that deep-sea mining will result in biodiversity loss and species level extinctions); *See generally* Diva J. Amon, Sabine Gollner, Telmo Morato, Craig R. Smith, Chong Chen, Sabine Christiansen, Brownwen Currie, Jeffrey C. Drazen, Tomohiko Fukushima, Matthew Gianni, Kristina M. Gjerde, Andrew J. Gooday, Georgina Guillen Grillo, Matthias Haeckel, Thembile Joyini, Se-Jonh Ju, Lisa A. Levin, Anna Metaxas, Kamila Mianowicz, Tina N. Molodtsova, Ingo Narberhaus, Beth N. Orcutt, Alison Swaddling, Joshua Tuhumwire, Patricio Urueña Palacio, Michelle Walker, Phil Weaver, Xue-Wei Xu, Clement Yow Mulalap, Peter E.T. Edwards, & Chris Pickens, *Assessment of Scientific Gaps Related to the Effective Environmental Management of Deep-Seabed Mining*, MARINE POL'Y 138 (2023) (assessing the level of scientific knowledge about environmental baselines and impacts from deep-sea mining and its management).

technological advances make exploitation easier and more efficient.[17] *Mare liberum*, the free use of the global commons, once prevailed as the main paradigm for activities in the ocean; however, with free use came overexploitation.[18] In response, States entered into specific multilateral treaties and developed nonbinding legal instruments to acknowledge and define obligations to protect the global commons from overexploitation and monopolization.[19] Aspects of these instruments have passed into customary international

[17] *See* Suzanne Iudicello & Margaret Lytle, *Marine Biodiversity and International Law: Instruments and Institutions that Can Be Used to Conserve Marine Biological Diversity Internationally*, 8 TUL. ENV'T. L.J. 123, 128 (1994) (documenting fisheries overexploitation and partially attributing overexploitation to improvements in technology); Ole Ritzau Eigaard, Paul Marchal, Henrick Gislason, & Adriaan D. Rijnsdorp, *Technological Development and Fisheries Management*, 22 REVS. IN FISHERIES SCI. & AQUACULTURE 156, 167 (2014) (discussing how improved technology improves fishing efficiency). The authors estimate that technological developments improve catchability by 3.2% per year. *Id*. [hereinafter Iudicello & Lytle]

[18] *See* Iudicello & Lytle, *supra* note 17; Nico Schrijver, *Managing the Global Commons: Common Good or Common Sink?*, THIRD WORLD QUARTERLY 30 (2016); Nico Schrijver & Vid Prislan, *From* Mare Liberum *to the Global Commons: Building on the Grotian Heritage*, GROTIANA 30 (2009).

[19] Iudicello & Lytle, *supra* note 17 (listing some fisheries agreements such as those that created fisheries regulatory bodies prior to UNCLOS in 1982 and the subsequent United Nations Fish Stocks Agreement (UNFSA) for the management of highly migratory and transboundary fish stocks, as well as other agreements for conserving living marine resources such as the Convention of the Conservation of Antarctic Marine Living Resources (CCAMLR), various conventions to protect birds, including marine species, and marine mammals, and the Convention on International Trade in Endangered Species (CITES)); Schrijver, *supra* note 18 (discussing treaty regimes to govern the global commons such as UNCLOS, the Fish Stocks Agreement, the Outer Space Treaty designating celestial bodies as global commons, treaties protecting Antarctic and Arctic resources, and the United Nations Framework Convention on Climate Change and non-binding legal instruments such as the Arctic Environmental Protection Strategy and the 1995 FAO Code of Conduct for Responsible Fisheries); Schrijver & Prislan, *supra* note 18, at 177, 181, 188 (also discussing treaties to govern the global commons). Another treaty to govern the global commons is the Biodiversity Beyond National Jurisdiction Agreement (BBNJ) is a new treaty to conserve and sustainably manage biodiversity on the high seas. The Agreement has been ratified by more than the minimum of 60 parties and will enter into force in January 2026, 120 days after the 60th ratification.

law.[20] Deep-sea mining is regulated through one of these treaties and its implementation agreement: the United Nations Convention on the Law of the Sea (UNCLOS) and the Agreement relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea (the 1994 Implementation Agreement).[21]

[20] Customary international law is a body of international legal practices that are 1) generally practiced and 2) to which a sense of legal obligation (*opinio juris*) is ascribed. JAN KLABBERS, INTERNATIONAL LAW 29 (2d ed. 2017). Some principles and norms of customary international law relating to the environment appear in environmental treaties and non-binding legal instruments and have gained status as customary international law in part through State practice and recognition by international courts and tribunals. Two examples are the requirement to conduct environmental impact assessments which appears in the United Nations Convention on the Law of the Sea (UNCLOS), the Madrid Protocol on the Antarctic Environment, and in Principle 17 of the non-legally binding Rio Declaration, and the prevention principle, which is partially stated in Principle 2 of the Rio Declaration. J. Ashley Roach, *Today's Customary International Law of the Sea*, Ocean Dev. & Int'l Law 45 (2014); Pierre-Marie Dupuy, Ginevra Le Moli, & Jorge E. Viñuales, *Customary International Law and the Environment*, in THE OXFORD HANDBOOK OF INTERNATIONAL ENVIRONMENTAL LAW 385 (Lavanya Rajamani & Jacqueline Peel eds., 2d ed. 2021). Two principles with disputed status as customary international law are also found in non-binding legal frameworks and treaties: the precautionary approach or principle and the concept of the "common heritage of humankind", both of which are discussed later in this article. Some authors claim the precautionary principle or approach may be customary international law while others suggest may be evolving towards customary international law status. ARIE TROUWBORST, EVOLUTION AND STATUS OF THE PRECAUTIONARY PRINCIPLE IN INTERNATIONAL LAW, (Klewer Law International 2002); Meinhard Schröder, *Precautionary Approach/Principle*, in MAX PLANCK ENCYCLOPEDIAS OF INTERNATIONAL LAW (2014). Some of the treaties environmental treaties that reference the precautionary principle are the Convention on Biological Diversity (CBD), the United Nations Framework Convention on Climate Change (UNFCCC), and the Fish Stocks Agreement and it is also referenced in Principle 15 of the Rio Declaration. Schröder, *supra* note 17. The concept of the common heritage of humankind, which designates certain resources and areas as owned by none and managed by all, is found in UNCLOS, the Outer Space Treaty, and the Antarctic Treaty System. Christopher C. Joyner, *Legal Implications of the Concept of the Common Heritage of Mankind*, 34 INT'L & COMP. LAW QUARTERLY 1 (1986), https://www.cambridge.org/core/product/identifier/S0020589300044201/type/journal_article [https://perma.cc/D4VU-3MXB].

[21] United Nations Convention on the Law of the Sea, arts. 1(1), 157(1), pt. XI §§ 4, 6, Dec. 10, 1982, 1833 U.N.T.S. 3 [hereinafter UNCLOS]; *see also* Agreement Relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea, July 28, 1996, 1836 U.N.T.S. [hereinafter 1994 Agreement].

Regulations that would govern commercial deep-sea mining in the Area are currently being negotiated by parties to UNCLOS and to the 1994 Implementation Agreement through the International Seabed Authority (ISA)—the international organization created by UNCLOS to oversee activities in the Area.[22] The industry is currently in the exploration phase—the phase prior to commercial exploitation—when States and their mining contractors survey areas allocated to them by the ISA for mineral deposits, test technology, and conduct environmental studies.[23] While it is clear from environmental studies that deep-sea mining will be devastating to local ecosystems at mining sites, gaps in scientific knowledge—including information about ecological interactions on the seafloor and in the water column, as well as understanding how complex ocean currents will transport mining waste products—make it difficult to predict the spatial extent, severity, and duration of environmental impacts and develop appropriate management measures.[24]

The high seas legal framework creates a system of rights and obligations that regulate use of the global commons by balancing exploitation of the global commons with marine ecosystem health.[25] With respect to deep-sea mining, UNCLOS requires States to protect the marine environment and to have "reasonable regard" for other activities in the ocean.[26] UNCLOS also designates the Area as

[22] *See* Catherine Blanchard, Ellycia Harrould-Kolieb, Emily Jones, & Michelle L. Taylor, *The Current Status of Deep-Sea Mining Governance at the International Seabed Authority*, 147 MARINE POL'Y 105395 (2023) (providing an overview of the ISA).

[23] *Id*. [Blanchard et al., 22] The exploration and exploitation phases of deep-sea mining will be discussed in more depth later in the article.

[24] Amon et al., *supra* note 16, at 11. Experts identified lack of scientific knowledge about the deep-sea as the primary barrier to minimizing environmental risks and ensuring effective marine protection from deep-sea mining. The second most critical barrier identified by experts was understanding the impacts of deep-sea mining; *See* Niner et al., *supra* note 6.

[25] Iudicello & Lytle, *supra* note 17, at 132.

[26] UNCLOS, *supra* note 21, arts. 145, 147(1). Both "reasonable regard" and "due regard" appear in UNCLOS due to a translation error from English to Spanish and back to English during the drafting but are equivalent terms. INT'L SEABED AUTH., ISA Technical Study No. 24, Deep Seabed Mining and Submarine Cables: Developing Practical Options for the Implementation of the 'Due Regard' and 'Reasonable Regard' Obligations under UNCLOS 8, n.3 (2019), p. 8; Bernard H. Oxman, *The Regime of Warships Under the United Nations Convention on the*

the "common heritage of [hu]mankind," and requires that activities in the Area ". . . be carried out for the benefit of [hu]mankind as a whole[.]"[27] This means that activities in the Area, particularly those that risk serious environmental harm, must be carefully evaluated.[28] UNCLOS is interpreted in tandem with the 1994 Implementation Agreement which modifies components of UNCLOS related to the Area.[29] Alongside these positive laws, international legal norms and principles require States to prevent environmental harm and proceed with caution where activities could cause severe or irreversible environmental impacts.[30] The current draft deep-sea mining regulations are insufficient to limit substantial and wide-reaching harms to marine ecosystems because they permit mineral exploitation despite serious gaps in scientific knowledge.

In this Article, we examine potential environmental impacts from deep-sea mining and explain the current legal obligations to protect ecosystems and biodiversity, and evaluate the draft mineral exploitation regulations for deep-sea mining through the ISA. Part II details the environmental impacts of deep-sea mining. Part III explains how deep-sea mining is governed in the Area. Part IV reviews the draft exploitation regulations currently under negotiation by ISA member states and evaluates whether the draft regulations

Law of the Sea, 24 VA. J. INT'L L. 810, 827 n.52, (1984). However, the term "reasonable regard" is used in the text of the Convention to refer to activities in the Area while the term "due regard" is not. UNCLOS, *supra* note 21, at art. 147(1), (3).

[27] UNCLOS, *supra* note 21, at arts. 136, 140(1).

[28] Joyner, *supra* note 20.

[29] The 1994 Implementation Agreement modifies provisions of part XI of UNCLOS (The Area) and instructs that UNCLOS and the 1994 Implementation Agreement must be treated as a single document, which this analysis does. 1994 Agreement, *supra* note 21, at art. 2. States must be parties to UNCLOS to be parties to the 1994 Implementation Agreement. *Id*. at art. 4(2); Two other implementing agreements under UNCLOS play a role in resource management in the high seas: the UNFSA and BBNJ. The UNFSA requires States to sustainably manage and conserve fish stocks that fall under the treaty's purview, while the BBNJ facilitates the conservation and sustainable use of biodiversity in the high seas.

[30] Pierre-Marie Dupuy & Jorge E. Viñuales, Chapter 3: The Principles of International Environmental Law in INTERNATIONAL ENVIRONMENTAL LAW 58 (Cambridge University Press 2nd ed) (2019).

effectively address the environmental concerns detailed in Part II.[31] Given the current state of scientific knowledge regarding the impacts of deep-sea mining on the environment, we argue that the current draft regulations are insufficient to prevent serious environmental harm. In Part V, we demonstrate that international law requires a moratorium on deep-sea mining until environmental impacts are better understood.

I. ENVIRONMENTAL IMPACTS

Deep sea mining is being proposed for three types of mineral deposits: polymetallic nodules, polymetallic sulfides, and cobalt-rich ferromanganese crusts.[32] Polymetallic nodules are potato-sized lumps of oxyhydroxides and manganese containing cobalt, among other minerals, copper, nickel, titanium, and rare earth elements.[33] The nodules are formed through the slow deposition of minerals over millions of years and are found on the abyssal seafloor where they blanket the benthic environment.[34] The nodules support abyssal ecosystems and host microorganisms with important carbon cycling roles.[35] Mining polymetallic nodules would involve collecting the

[31] *See* International Seabed Authority, *Draft Regulations on Exploitation of Mineral Resources in the Area*, U.N. doc. ISBA/29/C/CRP.1 (Feb. 16, 2024) [hereinafter Draft Regulations].

[32] *See* Blanchard et al., *supra* note 22, at 1, n.2.

[33] *See* Hein et al., *supra* note 8, at 158, 163; Kathryn A. Miller, Kirsten F. Thompson, Paul Johnston, and David Santillo*, An Overview of Seabed Mining Including the Current State of Development, Environmental Impacts, and Knowledge Gaps*, 4 FRONTIERS MARINE SCI. 1 2018, at 2, 3; S. Petersen, A. Krätschell, N. Augustin, J. Jamieson, J.R. Hein, M.D. Hannington, *News from the Seabed—Geological Characteristics and Resource Potential of Deep-Sea Mineral Resources*, MARINE POL'Y 2016, at 176, 178.

[34] *See* Jones et al., *supra* note 7, at 91; The abyssal ocean is the region of the ocean between 3,000 and 6,000 meters deep. The region deeper than 6,000 meters is the hadal zone. N.G. Vinogradova, *Zoogeography of the Abyssal and Hadal Zones*, ADVANCES MARINE BIO. 32 (1997). The benthic environment is the seabed and its ecological communities. *See* FRANCES DIPPER, *Benthic Living: Sublittoral and Deep Seabed*, in *Elements of Marine Ecology* 319, 319 (5th ed. 2022).

[35] *See* Massimiliano Molari, Felix Janssen, Tobias Vonnahme, Frank Wenzhöfer, & Antje Boetius, *Microbial Communities Associated with Sediments and Polymetallic Nodules of the Peru Basin*, 17 BIOGEOSCIENCES 3203 (2020); Vanreusel et al., *supra* note 13, at 1, 3; Tanja Stratmann, Lidia Lins, Autun Purser, Yann Marcon, Clara F. Rodrigues, Ascensão Ravara, Marina R. Cunha, Eric

nodules off the seafloor, pumping the slurry of nodules, sediment, and fauna up to a ship where nodules would be separated out, and then releasing the nodule-free slurry into the mid-water column.[36] Removing nodules from the seabed also removes fauna, creates light, noise, and particulate matter pollution, and would impair ecosystem function.[37] Research on abyssal food webs in nodule-rich environments demonstrates that nodule removal disrupts the food web through biodiversity loss.[38] Surveys from sites where nodules were removed show little faunal recovery even after nearly forty years and reduced microbial activity and impaired carbon cycling after nearly thirty years.[39]

Simon-Lledó, Daniel O.B. Jones, Andrew K. Sweetman, Kevin Köser, & Dick van Oevelen, *Abyssal Plain Faunal Carbon Flows Remain Depressed 26 Years After a Simulated Deep-Sea Mining Disturbance*, 4131 BIOGEOSCIENCES 15(13) (2018); Beth N. Orcutt, James A. Bradley, William J. Brazelton, Emily R. Estes, Jacqueline M. Goordial, Julie A. Huber, Rose M. Jones, Nagissa Mahmoudi, Jeffrey J. Marley, Sheryl Murdock, & Maria Pachiadaki, *Impacts of Deep-Sea Mining on Microbial Ecosystenm Services*, 1489 LIMNOLOGY AND OCEANOGRAPHY 65(7) 2020.

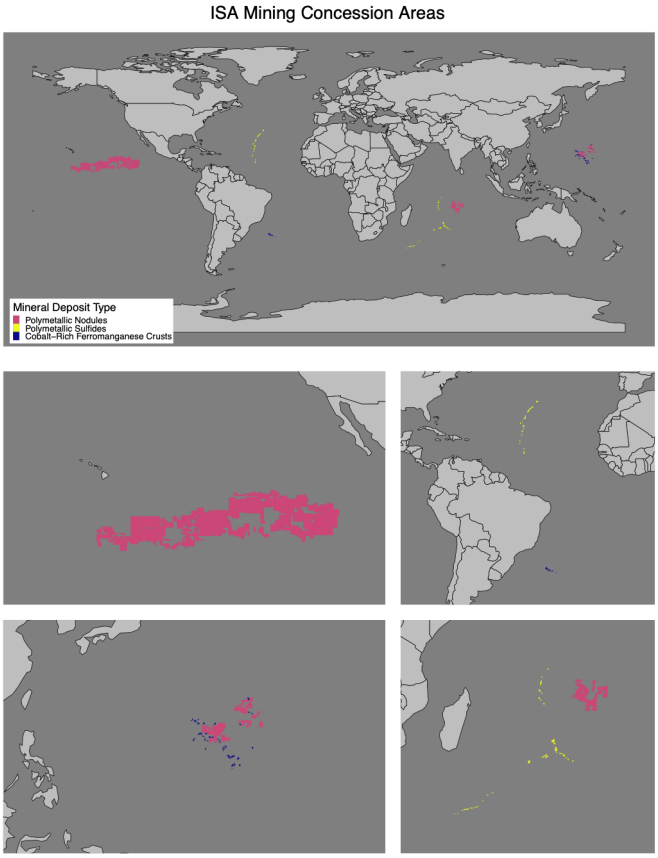
[36] *See* Jeffrey C. Drazen, Craig R. Smith, Kristina M. Gjerde, Steven H.D. Haddock, Glenn S. Carter, Anela C. Choy, C., Malcom R. Clark, Pierre Dutrieux, Erica Goetze, Chris Hauton, Mariko Hatta, Anthony J. Koslow, Astrid B. Leitner, Aude Pacini, Jessica M. Perelman, Thomas Peacock, Tracey T. Sutton, Les Watling, Hiroyuki Yamamoto, *Midwater Ecosystems Must be Considered When Evaluating Environmental Risks of Deep-sea Mining*, 117 PROC. NATL. ACAD. SCI. U. S. A. (PNAS) 17455, 17456 (2020).

[37] *See* Jones et al., *supra* note 7; Rob Williams, Christine Erbe, Alec Duncan, Kimberly Nielsen, Travis Washburn, & Craig Smith, *Noise from Deep-Sea Mining May Span Vast Ocean Areas*, 377 SCI. 157, 157 (2022).

[38] *See* Tanja Stratmann, Karline Soetaert, Daniel Kersken, & Dick van Oevelen, *Polymetallic Nodules are Essential for Food-Web Integrity of a Prospective Deep-Seabed Mining Area in Pacific Abyssal Plains*, 11 SCI. REPS., 2021, at 1, 7 (2021).

[39] Vanreusel et al., *supra* note 13, at 1, 5; Erik Simon-Lledó, Brian J. Bett, Veerle A.I. Huvenne, Kevin Köser, Timm Schoening, Jens Greinert, & Daniel O.B. Jones, *Biological Effects 26 Years After Simulated Deep-Sea Mining*, 1 SCI. REPORTS 9(1) (2019); Jones et al., *supra* note 7; Dmitry M. Miljutin, Maria A. Miljutina, Pedro Martínez Arbizu, & Joëlle Galéron, *Deep-Sea Nematode Assemblage has not Recovered 26 Years After Experimental Mining of Polymetallic Nodules (Clarion-Clipperton Fracture Zone, Tropical Eastern Pacific)*, 885 DEEP-SEA RESEARCH I 58(8) (2011); Stratmann et al., *supra* note 35; T.R. Vonnahme, M. Molari, F. Janssen, F. Wenzhöfer, M. Haeckel, J Titschack, & A. Boetius, *Effects of a Deep-Sea Mining Experiment on Seafloor Microbial Communities and Functions After 26 Years*, 1 SCI. ADVANCES 6(18) (2020);

Figure 1*:* ISA mining contract areas and corresponding mineral types.[40] Clockwise from the top left the four smaller plots are 1) the Clarion-Clipperton zone between Mexico and Hawai'i, the Atlantic Ocean, the Indian Ocean, and the northwestern Pacific Ocean.



[40] *See Exploration Contracts Maps*, INT'L SEABED AUTH., https://www.isa.org.jm/exploration-contracts/maps/ (containing the data source for the map) [hereinafter Exploration Contracts Maps]; R CORE TEAM, *R: A language and environment for statistical computing. R Foundation for Statistical Computing*, Ver. 2024.12.0+467, https://www.R-project.org/ (software used for the analysis), H. WICKHAM (2016). *ggplot2: Elegant Graphics for Data Analysis*. Springer-Verlag New York. ISBN 978-3-319-24277-4, https://ggplot2.tidyverse.org (the R package used to project the map); THOMAS LIN PEDERSEN (2025). *patchwork: The Composer of Plots*. R package version 1.3.2.9000, https://patchwork.data-imaginist.com (the R package used to edit the map).

Polymetallic sulfides are mineral precipitates that occur at hydrothermal vents and would be primarily targeted for iron, zinc, copper, lead, gold, and silver.[41] Hydrothermal vents are complex oases where superheated water exits the seafloor, heating the surrounding water, creating mineral deposits, and sustaining unique chemosynthetic ecosystems.[42] The vents occur around the geological formations known as mid-ocean ridges, back-arc spreading centers, and volcanic arcs.[43] Active hydrothermal vents are rare and fragile; they occupy about 50 km^2 of the planet and support unique and sometimes endemic fauna.[44] Active vents are temporary phenomena, they can be active for decades but become inactive and eventually extinct as the fluid flow shifts and tectonic and volcanic activity migrate the heat source.[45] Mining at hydrothermal vent sites is in the early stages of technological development but could involve

[41] *See* James R. Hein, Kira Mizell, Andrea Koschinsky, & Tracey A. Conrad, *Deep-Ocean Mineral Deposits As a Source of Critical Minerals for High-and Green-Technology Applications: Comparison with Land-Based Resources*, 1 ORE GEOLOGY REVS. 51 (2013); *Minerals: Polymetallic Sulphides*, INT'L SEABED AUTH., https://isa.org.jm/exploration-contracts/polymetallic-sulphides/ [https://perma.cc/8ZYS-GRJS] (last visited Jan. 5, 2026); Petersen et al., *supra* note 33, at 8–9.

[42] Jones et al., *supra* note 7, at 94–96; Miller et al., *supra* note 33.

[43] Jones et al., *supra* note 7.

[44] *See* C.L. Van Dover, S. Arnaud-Haond, M. Gianni, S. Helmreich, J.A. Huber, A.L. Jaeckel, A. Metaxas, L.H. Pendleton, S. Petersen, E. Ramirez-Llodra, P.E. Steinberg, V. Tunnicliffe, & H. Yamamoto, *Scientific Rationale and International Obligations for Protection of Active Hydrothermal Vent Ecosystems From Deep-Sea Mining*, 90 MARINE POL'Y 20, 20–21 (2018). Many hydrothermal vents meet the classification requirements for "Ecologically or Biologically Significant Marine Areas" (EBSAs) under the Convention on Biological Diversity, which is a scientific criterion for identifying rare and fragile marine ecosystems. EBSA designations are based on seven ecological criteria including biological rarity, biological productivity, and vulnerability. EBSA designations confer no legal obligation to protect the areas. After the "Lost City," a hydrothermal vent system on the Mid-Atlantic Ridge was identified as an EBSA site, the ISA awarded Poland a mining contract to extract polymetallic sulfides from the area without considering or noting the EBSA designation. David Edward Johnson, *Protecting the Lost City Hydrothermal Vent System: All is Not Lost, or is It?*, 107 MARINE POL'Y 103593 (2019), at 1, 2.

[45] *See* Jones et al., *supra* note 7, at 96; Van Dover et al., *supra* note 44; C.L. Van Dover et al., *Research is Needed to Inform Environmental Management of Hydrothermally Inactive and Extinct Polymetallic Sulfide (PMS) Deposits*, 121 MARINE POL'Y (2020).

flattening the seafloor and cutting out benches for the machines to sit on.[46] A rotating drum would carve out chunks of the seafloor, and the fragments would be pumped up in a slurry to the ship.[47] The operation would produce sediment plumes, which could disperse widely, causing impacts to fauna similar to those of polymetallic nodule mining.[48] Local fauna would be annihilated, and scientists do not know if individual vent ecosystems would be able to recover, nor whether there would be impacts on nearby vents.[49]

The third type of mineral resource is cobalt-rich ferromanganese crusts—metal deposits including cobalt, manganese, copper, iron, nickel, and platinum that form through precipitation on volcanic formations such as seamounts—which are biologically rich with complex, depth-dependent, heterogenous habitat.[50] Some of this habitat is created by benthic communities generally consisting of suspension feeders, such as deep-sea corals, sponges, clams and mussels, that create three-dimensional habitat that supports other taxa.[51] Fish and mobile pelagic species also use seamounts as habitat.[52] Seamounts can be sites of productive fisheries but are also

[46] *See* Jones et al., *supra* note 7, at 98; Petersen et al., *supra* note 33.

[47] *See* Jones et al., *supra* note 7.

[48] *See id*.

[49] *See generally* Lisa A. Levin, Amy R. Baco, David A. Bowden, Ana Colaco, Erik E. Cordes, Marina R. Cunha, Amanda W.J. Demopoulos, Judith Gobin, Benjamin M. Grupe, Jennifer Le, Anna Metaxas, Amanda N. Netburn, Greg W. Rouse, Andrew R. Thurber, Verena Tunnicliffe, Cindy Lee Van Dover, Ana Vanreusel, & Les Warling, *Hydrothermal Vents and Methane Seeps: Rethinking the Sphere of Influence*, 3 FRONTIERS MARINE SCI., 2016, at 1 (discussing current knowledge and uncertainties about hydrothermal vent ecosystems).

[50] *See* Jones et al., *supra* note 7; Miller et al., *supra* note 33; Petersen et al., *supra* note 33.

[51] *See* Jones et al., *supra* note 7; Lisa A. Levin, Kathryn Mengerink, Kristina M. Gjerde, Ashley A. Rowden, Cindy Lee Van Dover, Malcolm R. Clark, Eva Ramirez-Llodra, Bronwen Currie, Craig R. Smith, Kirk N. Sato, Natalya Gallo, Andrew K. Sweetman, Hannah Lily, Claire W. Armstrong, & Joseph Brider, *Defining "Serious Harm" to the Marine Environment in the Context of Deep-Seabed Mining*, 74 MARINE POL'Y 245, 252 (2016).

[52] *See* Telmo Morato, Simon D. Hoyle, Valerie Allain, & Simon J. Nicol, *Seamounts are Hotspots of Pelagic Biodiversity in the Open Ocean*, PNAS 107 (2010).

overexploited and thus vulnerable to further stress.[53] Mining for cobalt-rich ferromanganese crusts would likely be similar to mining for polymetallic sulfides and involve flattening the seafloor, cutting out benches, scooping out deposits, and sucking the slurry up to a ship.[54] Environmental impacts would be similar to those of polymetallic sulfides, with sediment, light, and noise affecting surrounding ecological communities and machinery eradicating fauna at the mining site.[55] Mining activity would destroy seamount fisheries, as well as important habitat for many other species.

Deep-sea mining is certain to cause severe localized environmental impacts, however with limited environmental data the nature and magnitude, including the broader spatiotemporal extent, remain poorly understood.[56] At the seafloor and subsurface levels, deep-sea mining will result in local extinctions and habitat loss, resulting in a permanent reduction in biodiversity, but the severity of impacts to ecosystems further away are difficult to predict given the current state of scientific knowledge about the deep sea.[57] Accordingly, it is difficult to develop management plans that predict and mitigate environmental impacts from deep-sea mining and decrease the risk of serious environmental harm from deep-sea mining.[58]

Pollution from light, sound, and particulate matter from deep-sea mining activities could interfere with life history strategies of deep-sea animals, including navigation, reproduction, feeding,

[53] *See* Ashley A. Rowden, John F. Dower, Thomas A. Schlacher, Mireille Consalvey, & Malcom R. Clark, *Paradigms in Seamount Ecology: Fact, Fiction and Future*, 31 MARINE ECOLOGY 226, 231–33 (2010).

[54] *See* Jones et al., *supra* note 7, at 98.

[55] *See id.*

[56] *See* Niner et al., *supra* note 6.

[57] *See id*; Lara Macheriotou, Annelien Rigaux, Sofie Derycke, & Ann Vanreusel, *Phylogenetic Clustering and Rarity Imply Risk of Local Species Extinction in Prospective Deep-Sea Mining Areas of the Clarion–Clipperton Fracture Zone*, 1 PROCS. ROYAL SOC'Y B: BIOLOGICAL SCIENCES 287 (2020); Cindy Lee Van Dover, *Impacts of Anthropogenic Disturbances at Deep-Sea Hydrothermal Vent Ecosystems: A Review*, 59 MARINE ENV'T RSCH. 102 (2014); C.L. Van Dover et al., *Biodiversity Loss from Deep-Sea Mining*, 10 NATURE GEOSCIENCE (2017); Vanreusel et al., *supra* note 13.

[58] *See* Lisa A. Levin, Diva J. Amon, & Hannah Lily, *Challenges to the Sustainability of Deep-Seabed Mining*, 3 NATURE SUSTAINABILITY 784, 786–87 (2020) (discussing how gaps in scientific knowledge impair sustainable deep-sea mining management).

predator avoidance, and communication.[59] Light from the mining vehicles would attract and confuse organisms adapted to the darkness who use bioluminescent light to attract mates and prey.[60] Sound from mining machinery and mining ships could travel long distances, and some species, such as whales, are highly sensitive to noise.[61] Noise pollution from deep-sea mining could drown out other sounds, for example obscuring communication, disrupt behavior, cause stress, and even hearing loss.[62] Particles made up of stirred-up seafloor sediment and particulate from the nodule-free slurry could become suspended in the water.[63] The particles could confuse visual, bioluminescent, and chemical signals relied on by organisms in the dark mid-water column,[64] introduce toxic metals into the water, and dilute the food supply of midwater suspension feeders with nutrient poor seafloor sediment potentially disrupting the pelagic food web.[65] Research on the impacts of suspended sediment on shallow water organisms reveals that it is a stressor; the

[59] *See* Drazen et al., *supra* note 36, at 17458; Williams, *supra* note 37.

[60] *See* Niner et al., *supra* note 6 (summarizing potential impacts to benthic ecosystems); *see* Drazen et al., *supra* note 36, at 17458 (summarizing potential impacts to midwater ecosystems).

[61] *See* Williams, *supra* note 37.

[62] *See id*.

[63] *See* Drazen et al., *supra* note 36.

[64] Ecosystems in this part of the ocean exist in complete darkness. The animals that live there are uniquely adapted to this darkness, relying, for example, on chemical signals and bioluminescence to carry out life functions such as reproduction and alimentation. *See* G.N. Somero, *Biochemical Ecology of Deep-Sea Animals*, 48 EXPERIENTIA 537, 537 (1992).

[65] *See* Drazen et al., *supra* note 36, at 17456; Chris Hauton, Alastair Brown, Sven Thatje, Nélia C. Mestre, Maria J. Bebianno, Inês Martins, Raul Bettencourt, Miquel Canals, Anna Sanchez-Vidal, Bruce Shillito, Juliette Ravaux, Magali Zbinden, Sébastien Duperron, Lisa Mevenkamp, Ann Vanreusel, Cristina Gambi, Antonio Dell'Anno, Roberto Danovaro, Vikki Gunn, & Phil Weaver, *Identifying Toxic Impacts of Metals Potentially Released During Deep-Sea Mining—A Synthesis of the Challenges to Quantifying Risk*, 4 FRONTIERS MARINE SCI. (2017); Emily K. Fallon, Matthias Frische, Sven Petersen, Richard A. Brooker, Thomas B. Scott, *Geological, Mineralogical and Textural Impacts on the Distribution of Environmentally Toxic Trace Elements in Seafloor Massive Sulfide Occurrences*, 9 MINERALS 162 (2019); Michael H. Dowd, Victoria E. Assad, Alexus E. Cazares-Nuesser, Jeffrey C. Drazen, Erica Goetze, Angelicque E. White, & Brian N. Popp, *Deep-Sea Mining Discharge Can Disrupt Midwater Food Webs*, 16 NATURE COMMUNICATIONS (2025).

sensitivity of deep-sea organisms to suspended sediment is unknown and could inform thresholds for particulate matter.[66] Effects of suspended metals on marine ecosystems are similarly unknown, as most studies have focused on freshwater ecosystems.[67] Researchers have estimated sedimentation rates and concentrations, but threshold concentrations for biological impacts are unknown.[68]

Biomass and biodiversity removal will impact trophic ecology with consequences for nutrient cycling in the deep-sea, however the scale and details of impact are still not well understood.[69] Although scientists have documented that nodule removal will disrupt abyssal food webs where mining occurs and similar localized trophic consequences can be inferred for polymetallic sulfide and

[66] *See* van der Grient & Drazen, *Evaluating Deep-Sea Communities' Susceptibility to Mining Plumes Using Shallow-Water Data*, SCI. TOTAL ENV'T 852 (2022) (establishing that suspended sediment is harmful to shallow water organisms, predicting that suspended sediment will also be harmful to deep-sea organisms, and emphasizing that deep-sea specific data is required to verify these results); Smith et al., *supra* note 12 (pointing out that data on organisms' sensitivity to suspended sediment comes primarily from research on shallow water ecosystems); Carlos Muñoz-Royo, Thomas Peacock, Matthew H. Alford, Jerome A. Smith, Arnaud Le Boyer, Chinmay S. Kulkarni, Pierre F. J. Lermusiaux, Patrick J. Haley Jr., Chris Mirabito, Dayang Wang, E. Eric Adams, Raphael Ouillon, Alexander Breugem, Boudewijn Decrop, Thijs Lanckriet, Rohit B. Supekar, Andrew J. Rzeznik, Amy Gartman, & Se-Jong Ju, *Extent of Impact of Deep-Sea Nodule Mining Midwater Plumes is Influenced by Sediment Loading, Turbulence, and Thresholds*, COMMC'NS EARTH & ENV'T, July 27, 2021, at 1, 12, https://www.nature.com/articles/s43247-021-00213-8#citeas [https://perma.cc/LCL4-JPKK] (discussing sedimentation from deep-sea mining and gaps in knowledge, asserting that more data is required to understand the biological impacts of suspended sediment to deep-sea biota).

[67] *See* Irene Martins, Alexandra Guerra, Ana Azevedo, Ombéline Harasse, Ana Colaço, Joana Xavier, Joana Soares, & Miguel M. Santos, *A Modelling Framework to Assess Multiple Metals Impacts on Marine Food Webs: Relevance for Assessing the Ecological Implications of Deep-Sea Mining Based on a Systematic Review*, 191 MARINE POLLUTION BULL., 2023, at 1–2.

[68] *See* Muñoz-Royo et al., *supra* note 66.

[69] *See* Drazen et al., *supra* note 36, at 17456. Trophic ecology refers to energy and biomass transfer in an ecosystem or between linked ecosystems through feeding interactions and food acquisition by organisms. Trophic interactions are critical for removing carbon from the sea surface into deep waters and for biological production in the deep-sea. *See* C.N. Trueman, G. Johnston, B. O'Hea, & K.M. Mackenzie, *Trophic Interactions of Fish Communities at Midwater Depths Enhance Long-Term Carbon Storage and Benthic Production on Continental Slopes*, 281 PROCS. ROYAL SOC'Y B 20140668, 20140559 (2014).

ferromanganese crust mineral extraction, it is still unclear how deep-sea mining would impact trophic ecology and carbon cycling further away from mining sites.[70] Impacts to benthic and mesopelagic food webs could affect the ocean's ability to sequester and store carbon, a crucial ecosystem service for alleviating the climate crisis.[71] But incomplete scientific information about deep-sea trophic ecology and uncertainty over the spatiotemporal impacts of deep-sea mining make it difficult to predict with reasonable certainty how deep-sea mining may impact ecosystems and ecological processes beyond the mining sites.

Advances in mining technology, modifications to the mining workflow, and minimizing the spatial scale of mining could reduce the severity of environmental impacts, although deep-sea mining would still severely impact deep-sea ecosystems. Benthic sediment clouds from polymetallic nodule mining could be minimized by modifying collector vehicles—which remove sediment along with

[70] *See* Amon et al., *supra* note 16; Drazen et al., *supra* note 36, at 17458. Disruption to food webs impacts carbon cycling because in marine ecosystems carbon is primarily recycled through trophic interactions. Connections between deep-sea benthic ecosystems and carbon cycling are just beginning to be understood; research demonstrates that nodule disturbance is linked to lasting interruptions in carbon flow through trophic interactions and hydrothermal vent activity has been documented to stimulate primary productivity in surface waters fueling the export of carbon from the atmosphere into the ocean. However, the level of influence of benthic ecosystems on carbon cycling is not yet understood. *See* Tim DeVries, *The Ocean Carbon Cycle*, 47 ANN. REV. ENV'T & RES. 317 (2022); Tanja Stratmann, Lidia Lins, Autun Purser, Yann Marcon, Clara F. Rodrigues, Ascensão Ravara, Marine R. Cunja, Erik Simon-Lledó, Daniel O.B. Jones, Andrew K. Sweetman, Kevin Köser, & Dick van Oevelan, *Abyssal Plain Faunal Carbon Flows Remain Depressed 26 Years After a Simulated Deep-Sea Mining Disturbance*, 15 BIOGEOSIENCES 413 (2018) (discussing the long-term impacts of deep-sea mining for polymetallic nodules on abyssal benthic ecosystems); Mathieu Ardyna, Léo Lacour, Sara Sergi, Francesco d'Ovidio, Jean-Baptiste Sallée, Matheiu Rembauville, Stéphane Blain, Alessandro Tagliabue, Reiner Schlitzer, Catherine Jeandel, Kevin Robert Arrigo, & Hervé Claustre, *Hydrothermal Vents Trigger Massive Phytoplankton Blooms in the Southern Ocean*, 10 NATURE COMMC'NS, (2019).

[71] *See* Drazen et al., *supra* note 36; Dowd et al., *supra* note 65; Mesopelagic food webs have critical roles in carbon cycling and also support deep-diving mammals and some commercial fish stocks. *Id*. [36 Drazen] We use the term "fish stocks" to refer to commercially exploited fish subpopulations and "fisheries" to refer to the commercial activity of fishing for a specific fish stock or stocks. High seas fisheries are large scale industrial fishing operations on the high seas. The majority of high seas fisheries exploit top predators such as tun, billfish, and sharks, however squid and rockfish are also exploited in the high seas.

nodules—to remove less sediment, shrouding the collector vehicles, or with robots that can pick up individual nodules.[72] Impacts to benthic ecosystems could be reduced by employing artificial intelligence to identify and avoid mesofauna on and around the nodules or by leaving portions of the seafloor intact such as through a network of protected areas reserved from mining.[73] Impacts to midwater fauna could be reduced by discharging the sediment plume from the vessel near the seafloor where disturbance from nodule mining has already occurred.[74] Reducing the size of mining sites would likely not reduce environmental impacts from polymetallic sulfide mining. Although polymetallic sulfides are small deposits, only about 0.57% of the 10,000 km^2 area allocated by the ISA for polymetallic sulfide exploration might be suitable for mining,[75]

[72] *See* Sebastian Ernst Volkmann & Felix Lehnen, *Production Key Figures for Planning the Mining of Manganese Nodules*, 36 MARINE GEORESOURCES & GEOTECHNOLOGY 3 (2017) (explaining potential polymetallic nodule mining technology); Van Dover, J.A. Ardron, E. Escobar, M. Gianni, K.M. Gjerde, A. Jaeckel, D.O.B. Jones, L.A. Levin, H.J. Niner, L. Pendleton, C.R. Smith, T. Thiele, P.J. Turner, L. Watling, & P.P.E. Weaver; *Robotic Collection System*, IMPOSSIBLE METALS, https://impossiblemetals.com/technology/robotic-collection-system/ [https://perma.cc/CFV5-EDHT] (last visited June 24, 2025).

[73] *See* IMPOSSIBLE METALS, *supra* note 72; Guofan Long, Wei Song, Xiangchun Liu, Ziyao Fang, Jinqi An, Kun Liu, Yaqin Huang, Xuebao He, *Automated Recognition of Deep-Sea Benthic Megafauna in Polymetallic Nodule Mining Areas Based on Deep Learning*, ECOLOGICAL INFORMATICS (2025); L.M. Wedding, A.M. Friedlander, J.N. Kittinger, L. Watling, S.D. Gaines, M. Bennett, S.M. Hardy, & C.R. Smith, *From Principles to Practice: A Spatial Approach To Systemic Conservation Planning in the Deep Sea*, 280 PROC. ROYAL SOCIETY B. (2013). We note that large portions of the areas designated for polymetallic nodule mining may be unsuitable for mining which may reduce mining impacts inside of the contract areas. A study of part of Germany's exploration contract area for polymetallic nodules in the Clarion Clipperton Zone of the Pacific revealed that only 36% of the area is suitable for mining due to factors such as nodule distribution and terrain that reduce mining efficiency. This study used a proposed mining system consisting of self-propelled vehicles that crawl along the seafloor collecting nodules that are then hydraulically lifted onto the ship. Volkmann & Lehnen, *supra* note 72.

[74] *See* Drazen et al., *supra* note 36; Muñoz-Royo et al., *supra* note 66.

[75] *See* Cyril Juliani & Steinar Løve Ellefmo, *Probabilistic Estimates of Permissive Areas for Undiscovered Seafloor Massive Sulfide Deposits on an Arctic Mid-Ocean Ridge*, 95 ONE GEOLOGY REV. 917 (2018); *See Exploration Areas*, ONE INT'L SEABED AUTH., https://www.isa.org.jm/exploration-contracts/exploration-areas/ [https://perma.cc/34RL-SNL8] (last visited June 25, 2025). The approximate percentage of the polymetallic sulfide exploration contract area suitable

mining would irreversibly alter or destroy vent ecosystems by removing vents in their entirety.[76] Mining technology and techniques for polymetallic sulfides are still in early development,[77] so technological strategies to reduce environmental impacts cannot be rigorously evaluated but environmental impacts to hydrothermal vents could be reduced by only mining on and around inactive vents or by strategically selecting areas that minimize disturbance and preserve ecosystem connectivity.[78] Technology for mining ferromanganese crusts is in an early phase of development so the environmental impacts cannot be evaluated; however, analysis of accessible mineral deposits suggests that mining activities could be relatively limited in spatial size.[79] In the case of ferromanganese crusts, an analysis of an area licensed to South Korea and its mining contractor for

for mining was calculated using data from Juliani and Ellefmo and the ISA. Along the study site of Mohn's Ridge in the Norwegian-Greenland Sea there is one active vent system with polymetallic sulfide deposits (Loki's Castle) and two inactive vent systems with polymetallic deposits (Mohn's Treasure and Copper Hill). The authors estimate there are also 11 undiscovered deposits bringing the total number to 14. 2,473.79 km^2 (or 55%) of Mohn's Ridge has geology favorable to polymetallic sulfide deposit formation and 141.12 km^2 (or 5.70%) of this area was considered highly favorable for deposit formation. We assume that all 14 deposits are approximately the size of Loki's Castle (approximately 0.057 km^2) for a combined area of 0.798 km^2 and fall within the 141.12 km^2 considered highly favorable for deposit formation, meaning that 0.57% of this area might contain minable polymetallic sulfide deposits. Using these assumptions 0.57% (or 57 km^2) of the 10,000 km^2 mineral areas allocated for polymetallic sulfide exploration by the ISA might be suitable for mining.

[76] *See* Van Dover et al, *supra* note 44.

[77] *See* Petersen et al., *supra* note 33.

[78] *See* Zenghui Liu, Kai Liu, Xuguang Chen, Zhengkuo Ma, Rui Lv, Changyun Wei, Ke Ma, *Deep-Sea Rock Mechanics and Mining Technology: State of the Art and Perspectives*, 33 INT'L J. MINING SCI. & TECH. 1083 (2023) (explaining current deep-sea mining technology); Van Dover et al., *supra* note 45; Daniel C. Dunn, Cindy L. Van Dover, Ron J. Etter, Craig R. Smith, Lisa A. Levin, Telmo Morato, Ana Colaço, Andrew C. Dale, Andrey V. Gebruk, Kristina M. Gjerde, Patrick N. Halpin, Kerry L. Howell, David Johnson, José Angel A. Perez, Marta Chantal Ribeiro, Heiko Stuckas, Philip Weaver, SEMPIA Workshop Participants, *A Strategy for the Conservation of Biodiversity on Mid-Ocean Ridges from Deep-Sea Mining*, 4 SCI. ADV. 7 (2018).

[79] *See* Liu et al., *supra* note 78; Petersen et al., *supra* note 33; Gyuha Hwang, Youngtak Ko, Seungjin Yang, & Wonnyon Kim, *Resource Abundance of Cobalt-Rich Ferromanganese Crusts in the KC-8 Seamount, West Pacific*, 12 FRONTIERS IN EARTH SCI., 2024, at 1, 2, 10.

mineral exploration found that only 20% of the area studied contain mineral deposits, and of those deposits only 82% are on slopes gentle enough for mining vehicles.[80] This means that only 16% of the area can be mined for ferromanganese crusts and the other 84% of the area would experience comparatively less environmental disturbance.[81] However, advances in ferromanganese crust mining technology could permit greater access to mineral deposits and larger spatial mining footprints.[82] The draft regulations neither prescribe technology nor limit the spatial extent of mining areas, beyond requiring that some areas be designated for conservation.[83] Using more environmentally friendly technologies and reserving areas from mining could have large positive environmental impacts, but the optional nature of these decisions may lead to inconsistent environmental standards.

Overfishing and climate change are already putting pressure on the sustainability of high seas fisheries by causing population declines, range shifts, and temperature and acidity-related physiological impacts and threatening food sources.[84] Further biodiversity loss

[80] Gyuha Hwang et al., *supra* note 79 (using the data presented in the paper we calculated percentage of the exploration contract area containing ferromanganese deposits by adding up the size of the 13 study blocks which are 20 km^2 for a total of 260 km^2 and dividing the total ferromanganese distribution area found in the paper which was 52.01 km^2 by this value for a total of 20%).

[81] *See id*. (to find the percentage of the spatial area of the contract area that could be mined we multiplied the total ferromanganese distribution area of 52.01 km^2 by percentage of the deposit that is on slopes gentle enough to be accessible by mining vehicles which was 82% and found that 42.65 km^2 of the study sites would be accessible to mining vehicles which can be converted to 16% of the study area by dividing this value by the total size of the study area which was 260 km^2).

[82] *See id*.

[83] *See* Draft Regulations, *supra* note 31, reg. 3.1.1.

[84] *See* William W.L. Cheung, Vicky W.Y. Lam, & Colette C.C. Wabnitz, *Future Scenarios and Projections for Fisheries on the High Seas under a Changing Climate*, (IIED 2019), https://www.iied.org/sites/default/files/pdfs/migrate/16653IIED.pdf [https://perma.cc/DJ5G-593X] (summarizing findings that unsustainable fishing and climate change are key threats to biodiversity and fish stocks); William W.L. Cheung, Vicky W.Y. Lam, Jorge L. Sarmiento, Kelly Kearney, Reg Watson, Dirk Zeller, & Daniel Pauly, *Large-Scale Redistribution of Maximum Fisheries Catch Potential in the Global Ocean Under Climate Change*, 16 GLOBAL CHANGE BIOLOGY 24 (2010) (demonstrating that climate change will cause range shifts for commercial exploited fish stocks altering where they can be caught); U. Rashid Sumaila, William W.L. Cheung, Vicky W.Y. Lam, Daniel

and pollution from deep-sea mining would magnify existing anthropogenic stressors on species and ecosystems, potentially impacting fish stocks.[85] Areas where deep-sea mining may occur spatially overlap with high seas fisheries.[86] Greater overlap is predicted as fish stocks shift poleward due to climate change.[87] Ecological

Pauly, & Samuel Herrick, *Climate Change Impacts on the Biophysics and Economics of World Fisheries,* NATURE CLIMATE CHANGE (2011) (predicting that climate change will impact fisheries productivity and the ecosystems that support fisheries leading to cascading impacts on fisheries catch eventually leading to social consequences); Juliano Palacios-Abrantes, Bianca S. Santos, Thomas L. Frölicher, Gabriel Reygondeau, U. Rashid Sumaila, Colette C.C. Wabnitz, & William W.L. Cheung, *Climate Change Drives Shifts in Straddling Fish Stocks in the World's Ocean*, SCI. ADVANCES (2025) (documenting that climate change will cause fish stocks shared between EEZs and the high seas to shift their ranges); William W.L. Cheung, Vicky W.Y. Lam, Jorge L. Sarmiento, Kelly Kearney, Reg Watson, & Daniel Pauly, *Projecting Global Marine Biodiversity Impacts Under Climate Change Scenarios*, 10 FISH & FISHERIES 235 (2009) (demonstrating that climate change will alter species' distributions worldwide, analysis includes marine fish); William W.L. Cheung, John Dunne, Jorge L. Sarmiento, & Daniel Pauly, *Integrating Ecophysiology and Plankton Dynamics into Projected Maximum Fisheries Catch Potential Under Climate Change in the Northeast Atlantic*, 68 ICES J. MARINE SCI. 1008 (2011) (predicting range shifts and lower catch potentials under climate change compared to simulations that did not integrate biogeochemistry and plankton community structure into their models); Malin L. Pinsky, Gabriel Reygondeau, Richard Caddell, Juliano Palacios-Abrantes, Jessica Spijkers, & William Cheung, *Preparing Ocean Governance for Species on the Move*, 360 SCI. POL'Y FORUM 1189 (2018) (discussing ocean governance must adapt to climate induced range shifts for commercially exploited fish stocks).

[85] We use the term "fish stocks" to refer to commercially exploited fish subpopulations and "fisheries" to refer to the commercial activity of fishing for a specific fish stock or stocks. High seas fisheries are large scale industrial fishing operations on the high seas. The majority of high seas fisheries exploit top predators such as tun, billfish, and sharks, however squid and rockfish are also exploited in the high seas. We also note that some fish stocks are highly migratory and may have ranges that include the national waters and exclusive economic zones of multiple States and the high seas.

[86] *See* van der Grient & Drazen, *Potential Spatial Intersection Between High-Seas Fisheries and Deep-Sea Mining in International Waters*, MARINE POL'Y 129 (2021) (discussing potential impacts from deep-sea mining to fisheries).

[87] *See* Diva J. Amon, Juliano Palacios-Abrantes, Jeffrey C. Drazen, Hannah Lily, Neil Nathan, Jess M. A. van der Grient, & Douglas McCauley, *Climate Change to Drive Increasing Overlap Between Pacific Tuna and Emerging Deep-Sea Mining Industry*, NATURE 1 (2023); International Seabed Authority, ISA Technical Study No. 33, Potential Interactions Between Fishing and Mineral Resource-Related Activities in Areas Beyond National Jurisdiction: A Spatial Analysis (2023) [hereinafter ISA Technical Study No. 33] (concluding that fishing over

stressors from deep-sea mining may result in altered ranges as megafauna avoid mining areas. Such shifts would necessitate altered fishing patterns.[88] Pollution from mining byproducts could travel up the food chain and bioaccumulate in commercially exploited predators, causing contamination that could threaten public health and impact biodiversity.[89]

Deep-sea mining operations, which would be centered around a ship while mining is occurring, could prove an impediment to fishing vessels operating in the same area.[90] High seas industrial fisheries use gear that ranges from less than a kilometer to 100 km in length, yielding a spatial footprint much larger than the boat itself. The majority of conflict would come with vessels trailing longlines and, to a lesser degree, purse seines that could get entangled with mining gear.[91] Where deep-sea mining overlaps both horizontally and vertically with high seas fisheries, as with trawlers fishing on

ISA contract areas represented 5–12% of vessels fishing on the high seas or 2% of the total high seas fishing hours between 2012 and 2020. Fishing can be measured in "fishing hours," which is the number of hours that vessels spend fishing. ISA Technical Study No. 33, *supra* note 87).

[88] *See* van der Grient & Drazen, *supra* note 86.

[89] *See* Hauton et al., *supra* note 65, at 2; Fallon et al., *supra* note 65, at 2; Martins et al., *supra* note 67. Issues related to pollution could have consequences for human health and could be exacerbated by lack of consumer regulations for such substances in many countries because contamination from deep-sea mining will not have been encountered before.

[90] Qi Zhang, Xuguang Chen, Lubao Luan, Fei Sha, Xuelin Liu, *Technology and Equipment of Deep-Sea Mining: State of the Art and Perspectives*, EARTH ENERGY SCI. (2024), https://doi.org/10.1016/j.ees.2024.08.002 [https://perma.cc/YVR2-6NYY]. Although fishing over areas where deep-sea mining may occur in the future represents a small proportion of high seas fishing activity mining would represent a significant impediment to overlapping fishing activity. ISA Technical Study No. 33, *supra* note 87.

[91] ISA Technical Study No. 33, *supra* note 87; Food and Agriculture Organization of the United Nations, Fishing Gear Types: Industrial Tuna Longline, https://www.fao.org/fishery/en/fishtech/1010/en [https://perma.cc/Z9VD-ALXN] (last visited Nov. 23, 2024); Food and Agriculture Organization of the United Nations, Fishing Gear Types: Purse Seine, https://www.fao.org/fishery/en/fishtech/40/en [https://perma.cc/XY3Q-HXG3] (last visited Nov. 23, 2024). Both sources provide background on fishing gear used by industrial fisheries such as those operating on the high seas.

the seafloor, it would likely compound the damage to fishing grounds.[92]

While there is uncertainty about the range and scale of impacts, scientists agree that deep-sea mining will reduce biodiversity, ecosystem health, impact fisheries, influence carbon sequestration, and potentially harm public health. Environmental impacts will be unavoidable, and substrates and habitat cannot be replicated making restoration impossible.[93] With these acknowledged impacts, we expect international law to play a role in protecting biodiversity and ocean health as the ISA considers if and how to develop a deep-sea mining regime. The following section explains the international laws that govern deep-sea mining, and Section IV walks through the currently proposed regulatory framework.

II. GOVERNANCE

A deep-sea mining regime under the ISA would occur in areas of the deep seafloor beyond the jurisdiction of any State, a region known as "the Area." Deep-sea mining in the Area is exclusively governed by UNCLOS—which elaborates the legal framework for global oceans and governs marine activities and marine natural resource uses—and the 1994 Implementation Agreement—which modifies provisions related to deep-sea mining.[94] UNCLOS established the framework to manage the Area, including designating it as the common heritage of humankind, set up a deep-sea mining regime, and created the ISA.[95] UNCLOS articulates legal obligations to protect the marine environment and manage activities such as fishing, deep-sea mining, and marine scientific research.[96] The 1994 Implementation Agreement affirms obligations in UNCLOS to protect the marine environment and promote marine scientific research in the Area.[97] Alongside the treaty language of UNCLOS, principles and norms of international environmental law such as the

[92] Where trawling and deep-sea mining spatially overlap both activities would represent physical impediments to each other. ISA Technical Study No. 33, *supra* note 87.

[93] Niner et al., *supra* note 6; Tunnicliffe, *supra* note 10.

[94] UNCLOS, *supra* note 21, § 4.

[95] *See id*. art. 136.

[96] *See id*. at arts. 87, 145, 147, 192.

[97] *See* 1994 Agreement, *supra* note 21, at Annex (Section 1)(5)(g–k).

due diligence standard, the environmental impact assessments, and the precautionary approach hold States to standards of conduct that require them to avoid or minimize environmental impacts, conduct risk assessments, and to take precautions when actions may cause irreversible and potentially severe environmental impacts.[98]

This section first describes the governing treaties (UNCLOS and the 1994 Implementation Agreement) and discusses the mandate to protect the marine environment while also allowing for sustainable exploitation of marine resources.[99] Following this

[98] *See* Dupuy & Viñuales, *supra* note 30, at 393–95.

[99] The UNFSA and BBNJ Agreements pertain to marine resource exploitation and ecosystem management but are less relevant to deep-sea mining, so discussion of these treaties is limited to this footnote. The UNFSA operationalizes Article 63 of UNCLOS, which deals with the "conservation and management" of transboundary and highly migratory fish stocks. States must "assess the impacts of fishing, other human activities, and environmental factors on target stocks and species in the same ecosystem, associated with, or dependent upon the target stocks" (art. 3(1)). While the obligation to conserve and manage fish stocks is limited in scope—applying only to species and ecosystems covered under the treaty—the obligation to assess the impacts of other human activities may require member States to conduct research on the environmental impacts from deep-sea mining on fish stocks and pelagic ecosystems. In its advisory opinion on climate change, ITLOS observed that for conservation measures under the UNFSA to be effective, they must take into account the impacts of climate change on fish stocks and fisheries (at para. 410). It also noted that as it stated in the *Southern Bluefin Tuna* cases, "the conservation of the living resources of the sea is an element in the protection and preservation of the marine environment" (at para. 70). If deep-sea mining were to impact fish stocks under the Agreement's purview as some researchers have suggested it may (see Drazen, *supra* note 36 & van der Grient & Drazen, *supra* note 86), an obligation to develop management measures under the Agreement that alleviate these impacts could be triggered. The obligation would be limited in scope, conservation and management measures under the Agreement apply narrowly to transboundary and straddling fish stocks (art. 3(1)), and "where necessary" to "species belonging to the same ecosystem or associated with or dependent upon the target stocks" (art. 5(e)). However, this limitation would likely not preclude fisheries management organizations from working with the ISA, for example to avoid deep-sea mining in areas important for fisheries, or for member States at the ISA, many of which are parties to the UNFSA, from advocating for fisheries friendly measures in the draft regulations. The BBNJ covers exploitation and benefit sharing of genetic resources from the ocean, area-based management tools for managing biodiversity, environmental impact assessments, and capacity building and technology transfer. The BBNJ must be "interpreted and applied in a manner that does not undermine relevant legal instruments and frameworks and relevant global, regional, subregional and sectoral bodies" (art. 5(2)), which means that the BBNJ cannot encroach on the ISA's competencies. Klaas Willaert &

description of international treaties is an exploration of principles and norms of international environmental law, which require States to protect biodiversity and proceed cautiously with environmentally harmful activities. We describe the general governance structure for deep-sea mining and then explain how deep-sea mining regulations fit into this framework.

A. *The United Nations Convention on the Law of the Sea*

UNCLOS is the legal framework for international ocean governance. It articulates the maritime rights and duties of States. The text was finalized in 1982 and has been ratified by 166 out of 193 United Nations States as well as by one United Nations observer State, two non-member States (Cook Islands and Niue), and the European Union, making it one of the most widely ratified United Nations treaties.[100] Aspects of the UNCLOS, particularly those relating to navigation and maritime boundaries, are considered customary international law and therefore apply to States that are not parties.[101]

Anemoon Soete, *The Interaction Between the BBNJ Agreement and the International Deep Sea Mining Regime: More Questions than Answers?*, 56 OCEAN DEV. & INT'L LAW 2 (2025). However, the BBNJ must also be "interpreted and applied in a manner that . . . promotes coherence and coordination with [the previously mentioned] instruments, frameworks, and bodies" (art. 5(2)), suggesting that the BBNJ could be a tool to enhance the ISA's obligations, particularly for environmental management, which is a core focus of the BBNJ. Willaert, *supra* note 99. This may mean that the Agreement could be deployed synergistically alongside the ISA's deep-sea mining regulatory framework to enhance implementation of environmental management at the ISA (such as through co-designed environmental management efforts) but could not be deployed in a way that interferes with the ISA's development or implementation of the deep-sea mining regulatory scheme.

[100] United Nations Treaty Collection, *United Nations Convention on the Law of the Sea*, https://treaties.un.org/Pages/ViewDetailsIII.aspx?src=TREATY&mtdsg_no=XXI-6&chapter=21&Temp=mtdsg3&clang=_en [https://perma.cc/V3JG-JRH9] (last visited Aug. 4, 2025).

[101] Roach, *supra* note 20 (identifying which parts of UNCLOS may be customary international law); Martin Lishexian Lee, *The Interrelation Between the Law of the Sea Convention and Customary International Law*, 7 SAN DIEGO INT'L L.J. 405 (2006) (asserting at least a large portion of UNCLOS is customary international law); *See* Delimitation of the Continental Shelf between Nicaragua and Colombia beyond 200 Nautical Miles from the Nicaraguan Coast (Nicar. v. Colom.), 2023 I.C.J. Rep. 415 (July 13). The court decided *Nicaragua v. Colombia* citing principles of customary international law first articulated in UNCLOS. Colombia is not a party to UNCLOS so this case could not be brought by Nicaragua under

UNCLOS divides the water column and seabed into governance zones and outlines State obligations in those zones. The Convention designates the seabed and subsoil, including the non-biological resources, beyond national jurisdiction—"the Area"—as the "common heritage of [hu]mankind," which scholars have interpreted to mean that the resources must be administered for the benefit of humanity, although how to administer the resources for the benefit of humankind is contested.[102] For example, States disagree over whether or not to extract the mineral resources in the Area and how to administer deep-sea mining in ways that socially and economically benefit developing States.[103]

Under UNCLOS, States must protect the marine environment while balancing marine activities and resource uses.[104] States have rights to conduct activities on the high seas, limited by the requirement to have "due regard" for the rights of other States also conducting activities on the high seas.[105] Included are the rights to fish and to conduct scientific research.[106] Other rights relate to navigation by water and air, the right to lay submarine cables and pipelines, and the right to construct artificial islands and installations.[107]

1. The International Seabed Authority

UNCLOS created the ISA, an autonomous international organization that came into being in November 1994, to "organize and

UNCLOS but principles of UNCLOS could still be considered by the court because they are principles of customary international law.

[102] UNCLOS, *supra* note 21, at arts. 1(1), 136, 140(1)–(2). Areas beyond national jurisdiction are beyond the exclusive economic zones and continental shelves of coastal nations, approximately 64% of the ocean's surface area and 95% of its volume. Article 136 designates the Area's mineral resources as "the common heritage of [hu]mankind," and Article 140 paragraph 1 requires that activities in the Area be carried out for "the benefit of [hu]mankind as a whole." Aline Jaeckel, *Benefiting From the Common Heritage of Humankind: From Expectation to Reality,* 35 INT'L J. MARINE AND COASTAL L. 660, 660 (2020) (examining six categories of benefits that could be derived from the seabed and noting that this is a non-exhaustive list).

[103] Jaeckel, *supra* note 102.

[104] *See* UNCLOS, *supra* note 21, at arts. 145, 147(1), 147(3).

[105] *Id*. at art. 87.

[106] *Id*. at art. 87(1)(e)–(f).

[107] *Id*. at art. 87(1)(a)–(d).

control activities in the Area, particularly with a view to administering the [mineral] resources of the Area."[108] The ISA manages the common heritage of humankind located in the Area for the benefit of humankind.[109] All States that are party to UNCLOS are also ISA member states and may participate in governance of the Area through the ISA.[110]

The ISA is based in Kingston, Jamaica and is composed of three principal bodies: an assembly, a council, and a secretariat (Figure 2).[111] The Assembly is composed of the member States that vote on general policies, elect the head of the Secretariat (the Secretary-General) and members of the Council, set the budgets, examine reports from other bodies, and approve regulations for mineral exploration and exploitation.[112] The Assembly also contains the Finance Committee, which oversees the ISA's financial management.[113] The Council's job is to implement the duties and obligations prescribed by UNCLOS and by regulations for mineral exploration and exploitation, including approving or denying applications for mineral exploration or exploitation.[114] The Council is composed of thirty-six

[108] *Id*. at art. 133(a), 156(1), 157(1); *see About ISA,* INT'L SEABED AUTH., https://www.isa.org.jm/about-isa/ [https://perma.cc/MLB7-DDTS] (last visited Jan. 7, 2025); Article 133(a) defines resources as "all solid, liquid, or gaseous mineral resources *in situ* in the Area at or beneath the seabed…"); Michael Wood, *International Seabed Authority: The First Four Years*, 3 Max Plank U.N. Y.B. (1999), https://www.mpil.de/files/pdf2/mpunyb_wood_3.pdf [https://perma.cc/G88N-U2E3].

[109] *See* UNCLOS, *supra* note 21, at art. 140(1); *See* Prue Taylor, The Common Heritage of Mankind: A Bold Doctrine Kept Within Strict Boundaries, in THE WEALTH OF COMMONS (2012), https://wealthofthecommons.org/essay/common-heritage-mankind-bold-doctrine-kept-within-strict-boundaries [https://perma.cc/KUL5-ZD9S].

[110] *See* UNCLOS, *supra* note 21, at art. 156(2).

[111] *Id*. at arts. 156(2), 158.

[112] *Id*. at art. 159–60; *see also The Assembly*, INT'L SEABED AUTH., https://www.isa.org.jm/organs/the-assembly/ [https://perma.cc/WS3R-XXWR] (last visited Feb. 13, 2025).

[113] *See* G.A. Res. 48/263, U.N. Doc. A/RES/48/263 (Aug. 17, 1994); *see The Finance Committee,* INT'L SEABED AUTH., https://www.isa.org.jm/organs/the-finance-committee/ [https://perma.cc/3VD5-NJMN] (last visited Feb. 14, 2025).

[114] *See* UNCLOS, *supra* note 21, at art. 161–62; *see also The Council,* INT'L SEABED AUTH., https://www.isa.org.jm/organs/the-council/ [https://perma.cc/KP8D-US8X] (last visited Feb. 13, 2025).

elected member States divided into five groups composed of two groups of four, one group of six, and one group of eighteen.[115] These five groups are States that are major (1) consumers of minerals that would be derived from deep-sea mining (Group A), (2) deep-sea mining investors (Group B), (3) exporters of minerals that would be derived from deep-sea mining (Group C), (4) special interests groups, including small island developing States, populous States, landlocked or geographically disadvantaged States, least developed States, States which are major importers of minerals that would be derived from deep-sea mining, States which are major producers of these minerals (Group D), and (5) States from each geographic region for equitable geographical representation (Group E) (Figure 2).[116] Within the Council are two organs (Figure 2): the Economic Planning Commission and the Legal and Technical Commission.[117] The Economic Planning Commission focuses on economic topics and reviews and proposes measures regarding mineral market trends relevant to deep-sea mining.[118] The Legal and Technical Commission focuses on legal and scientific topics, develops environmental management plans, makes recommendations to the Council on issues related to mineral exploration and exploitation, and reviews mineral exploration and exploitation applications and activities.[119] The Secretariat consists of the Secretary-General and support staff (Figure 2).[120] The Secretary-General is the chief administrative officer.[121] The final organ of the ISA is the Enterprise, a semi-autonomous organ of the ISA through which developing States can

[115] *See* UNCLOS, *supra* note 21, at art. 161(1); 1994 Agreement, *supra* note 21, at Annex, sec. 3(15).

[116] *Id.*

[117] *Id*. at art. 163(1–2).

[118] *Id*. at art. 164; *see Organs of the International Seabed Authority,* INT'L SEABED AUTH., https://www.isa.org.jm/organs/ [https://perma.cc/49EM-Z7WE] (last visited Feb. 13, 2025).

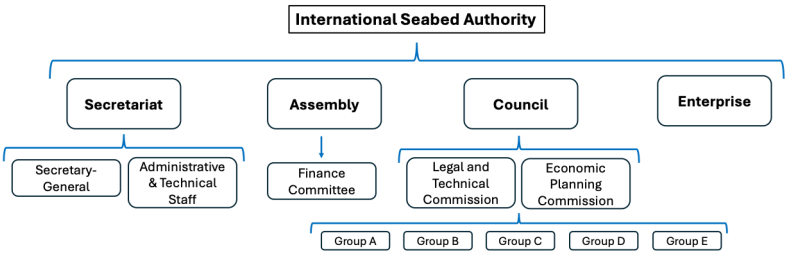
[119] *See* UNCLOS, *supra* note 21, at art. 165; *see The Legal and Technical Commission*, INT'L SEABED AUTH., https://www.isa.org.jm/organs/the-legal-and-technical-commission/ [https://perma.cc/6VU5-CEZA] (last visited Feb. 13, 2025).

[120] *See* UNCLOS, *supra* note 21, at art. 166; *see The Secretariat*, INT'L SEABED AUTH., https://www.isa.org.jm/organs/the-secretariat/ [https://perma.cc/DY8G-QR4H] (last visited Feb. 14, 2025).

[121] *See* UNCLOS, *supra* note 21, at art. 167.

participate in deep-sea mining (Figure 2).[122] The Enterprise is not yet operational but would function as a mining operator, carrying out deep-sea mining on behalf of developing States.[123] The Enterprise would be responsible for multiple supply chain steps beyond mining, such as mineral transport, processing, and marketing.[124] It would also be responsible for (among others) monitoring trends and developments in deep-sea mining including global metal markets, assessing the results of marine scientific research—especially research related to environmental impacts of deep-sea mining—available data for mineral prospecting and exploration, and technological developments for environmental protection and preservation.[125]

Figure 2: ISA organization structure.[126]



As part of its responsibility to administer resource management, the ISA has identified mineral deposit locations. These ISA-designated sites are for (1) polymetallic sulfides and nodules in the Indian Ocean, (2) polymetallic sulfides and ferromanganese crusts in the Pacific Ocean, and (3) polymetallic sulfides and

122 *See* UNCLOS, *supra* note 21, at art. 170; Klass Willaert, *The Enterprise: State of Affairs, Challenges, and Way Forward*, 131 MARINE POL'Y 1 (2021); Mehdi Remaoun, *The International Seabed Authority and the Enterprise: How Africa is Reinvigorating the Principle of the Common Heritage of Mankind*, J. OCEAN GOV. AFRICA 1 (2021).

123 *See* Willaert, *supra* note 122.

124 *See id*. at 2.

125 *See* 1994 Agreement, note 21, at Annex (Section 2)(1)(a–d).

126 *See Organs of the International Seabed Authority*, INT'L SEABED AUTH., https://www.isa.org.jm/organs/ [https://perma.cc/49EM-Z7WE] (last visited Aug. 1, 2025).

ferromanganese crusts in the Atlantic Ocean (see Figure 1).[127] The regions are further divided into management units, with some designated for mineral mining activity, and others withheld for monitoring transboundary impacts or for conservation.[128] The ISA also facilitates research in the Area. These services include supporting a repository of scientific data, supporting and administering training and capacity development for marine scientific research and mineral extraction, supporting projects related to the development of ocean-based economies, carrying out deep-sea taxonomic research, and fostering ocean literacy.[129]

While commercialized industrial mining has not begun yet, the ISA has approved regulations allowing *exploration* of polymetallic nodules, polymetallic sulfides, and ferromanganese crusts and is currently developing regulations for *exploitation* of these mineral deposits.[130] Exploration and exploitation are different phases of

[127] *See* Exploration Contracts Maps, *supra* note 40.

[128] *See Guidance to Facilitate the Development of Regional Environmental Management Plans (REMPs)*, INT'L SEABED AUTH., at 3.12 (Dec. 2022), https://www.isa.org.jm/wp-content/uploads/2022/12/remp_guidance_.pdf [https://perma.cc/GNM7-NABU]; ISA Technical Study No. 33, *supra* note 87; Areas of Particular Environmental Interest (APEIs) are designated by the ISA for protection from mining. There are currently 13 APEIs, all of which are in the Clarion Clipperton Region, which make up a total of 1.97 million km^2. ISA Technical Study No. 33, *supra* note 87.

[129] *See DeepData Database*, INT'L SEABED AUTH., https://www.isa.org.jm/deepdata-database/ [https://perma.cc/44JV-43QL] (last visited Nov. 23, 2024); *Capacity Development, Training and Technical Assistance*, INT'L SEABED AUTH., https://www.isa.org.jm/capacity-development-training-and-technical-assistance/ [https://perma.cc/QA9L-VT4F} (last visited Nov. 23, 2024); *Supporting Africa's Blue Economy*, INT'L SEABED AUTH., https://www.isa.org.jm/isa-voluntary-commitments/supporting-africas-blue-economy/ [https://perma.cc/D2X2-RSYF] (last visited Nov. 23, 2024); *Advancing Deep-Sea Taxonomy*, INT'L SEABED AUTH., https://www.isa.org.jm/isa-voluntary-commitments/advancing-deep-sea-taxonomy/ [https://perma.cc/R3DX-G7BN] (last visited Nov. 23, 2024); *Promoting Deep-Sea Literacy*, INT'L SEABED AUTH., https://www.isa.org.jm/isa-voluntary-commitments/promoting-deep-sea-literacy/ [https://perma.cc/RTF6-4RD6] (last visited Nov. 23, 2024).

[130] *See* Wood, *supra* note 108, at 185–86; Blanchard, et al., *supra* note 22, at 2–3; Draft Regulations, *supra* note 31, at Regul.15(3)(b); *Decision of the Council of the International Seabed Authority Relating to Amendments to the Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area and Related Matters,* INT'L SEABED AUTH., 1(3)(a-b), U.N. doc. ISBA /19/C/17 (July 22, 2013) [hereinafter Polymetallic Nodule Exploration Regulations]; *Decision of the*

mineral development. Deep-sea mining is currently in the exploration phase, as contractors search for and study mineral deposits on the seafloor, test technology for harvesting the mineral deposits, and conduct environmental, economic, or other relevant studies.[131] Exploitation is the harvesting of mineral deposits for commercial purposes.

The environmental data, excluding geological data, collected during the exploration phase is stored in the ISA's publicly accessible DeepData Database.[132] This data can be used to establish environmental baselines against which deep-sea mining impacts can be compared. It has facilitated progress in scientific knowledge about the Area, such as enabling the first estimation of species richness in one of the mineral exploration zones.[133] However, an analysis of the database has revealed data quality issues such as duplicates, missing fields, and a lack of unique identifiers for taxonomic records, which impair the data's usefulness and accessibility.[134]

Regulations are drafted by the Legal and Technical Commission of the ISA following expert workshops, studies, and discussion papers.[135] The Commission submits the draft regulations for review

Assembly of the International Seabed Authority Relating to the Regulations on Prospecting and Exploration for Polymetallic Sulphides in the Area, INT'L SEABED AUTH., 1(3)(a-b), U.N. doc. ISBA /16/A/12/Rev.1 (Nov. 15, 2010) [hereinafter Polymetallic Sulphides Exploration Regulations]; *Decision of the Assembly of the International Seabed Authority Relating to the Regulations on Prospecting and Exploration for Cobalt-rich Ferromanganese Crusts in the Area*, INT'L SEABED AUTH., reg. 1(3)(b-c), U.N. doc. ISBA /18/A/11 (Oct. 22, 2012) [hereinafter Ferromanganese Crusts Exploration Regulations].

131 *See* Polymetallic Nodule Exploration Regulations, *supra* note 130, at reg. 1(3)(a-b); Polymetallic Sulphides Exploration Regulations, *supra* note 130, reg. 1(3)(a-b); Ferromanganese Crusts Exploration Regulations, *supra* note 130, at reg. 1(3)(b-c).

132 *See DeepData Database*, INT'L SEABED AUTH., ver. 1.1 (2018).

133 Muriel Rabone, Joris H. Wiethase, Erik Simon-Lledó, Aiden M. Emery, Daniel O.B. Jones, Thomas G. Dahlgren, Guadalupe Bribiesca-Contreras, Helena Wiklund, Tammy Horton, & Adrian Glover, *How Many Metazoan Species Live in the World's Largest Mineral Exploration Region*, 33 CURRENT BIOLOGY 2383 (2023).

134 *See* M. Rabone, T. Horton, D.O.B. Jones, E. Simon-Llédo, & A. Glover, *A Review of the International Seabed Authority Database DeepData from a Biological Perspective: Challenges and Opportunities in the U.N. Ocean Decade,* DATABASE (2023).

135 *See* Blanchard, et al., *supra* note 22, at 2–3.

by ISA member States, which establish informal working groups to review the regulations.[136] Regulations for mining are negotiated at the ISA's annual sessions by member States and agreed on through consensus.[137] Divergent views on major regulatory issues, inadequate time for discussion and insufficient information on these topics have delayed negotiations.[138]

The deep-sea mining industry has been in a developmental stage for many years.[139] Countries first took an interest in mining polymetallic nodules in the 1960s, but shelved the projects in the 1980s before commercial exploitation could take place.[140] Interest in deep-sea mining in the Area was diminished by a combination of cheaper metal prices, the designation of the Area as the common heritage of humankind which favors benefits to humankind over private or national enrichment, the discovery of deep-sea mineral deposits within exclusive economic zones, and a greater understanding of the technological and environmental challenges of deep-sea mining.[141] The ISA has allowed exploration for polymetallic nodules since 2001, polymetallic sulfides since 2010, and ferromanganese crusts since 2012.[142] It has been developing rules and regulations for the exploitation of polymetallic nodules, polymetallic sulfides, and ferromanganese crusts in the Area since 2014.[143]

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136 *Id*. at 4.

137 *Id*. Parties to UNCLOS are by default members of the ISA. Non-parties to UNCLOS cannot be members of the ISA. UNCLOS, *supra* note 21, at art. 156(2).

138 *See* Chris Pickens, Hannah Lily, Ellycia Harrould-Kolieb, Catherine Blanchard, Anindita Chakraborty, *From What-If to What-Now: Status of the Deep-Sea Mining Regulations and Underlying Drivers for Outstanding Issues*, 169 MARINE POL'Y 1, 2 (2024). We discuss the regulatory issues that have delayed negotiations in greater detail in Part IV of the paper.

139 *See* Wood, *supra* note 108 (explaining that there have been several registered pioneer investors since 1997).

140 *See* Ole Sparenberg, *A Historical Perspective on Deep-Sea Mining for Manganese Nodules, 1965–2019*, EXTR. INDUS. SOC. (2019).

141 *See id*.

142 *See* Polymetallic Nodule Exploration Regulations, *supra* note 130; Polymetallic Sulphides Exploration Regulations, *supra* note 130; Ferromanganese Crusts Exploration Regulations, *supra* note 130.

143 *See* Pradeep A. Singh, *The Invocation of the 'Two-Year Rule' at the International Seabed Authority: Legal Consequences and Implications*, INT'L J. MARINE & COASTAL L. 37 (2022), https://doi.org/10.1163/15718085-bja10098 [https://perma.cc/TF63-YQTY]; In 2011 Fiji requested the Council to begin

The draft regulations outline the content and structure of applications for exploitation contracts.[144] They contain the rights and obligations of States and contractors, including those related to protecting the marine environment.[145] They clarify contractual and financial issues, such as when and how a mining contract can be modified or terminated and details related to financing and fees.[146] Topics related to data transparency are also clarified, such as what types of information must be gathered, what information is confidential, and what information must be made publicly available by the State and contractor.[147] They also contain information related to enforcement and disputes, such as how the regulations would be enforced and procedures for dispute settlement.[148] Finally, the draft regulations contain procedures for reviewing and revising the regulations.[149]

Nauru triggered a push to finalize exploitation regulations by invoking a rule requiring the completion of regulations within two years if requested by a State that intends to submit an application for exploitation.[150] The two-year deadline to complete regulations expired in 2023 without action by the ISA to finalize the regulations, the ISA agreed to instead adopt regulations by July 2025 but failed to meet this deadline as well.[151] If Nauru submits an application for

considering the development of rules and regulations for mineral exploitation but the Legal and Technical Commission did not start drafting the regulations until 2014. International Seabed Authority, *Status of the Draft Regulations on Exploitation of Mineral Resources in the Area and Proposed Road Map for 2022 and 2023*, U.N. doc. ISBA/26/C/44 2021 (Aug. 23, 2021).

144 *See* Draft Regulations, *supra* note 31, at pt. II.

145 *Id.* at pt. III.

146 *Id.* at pt. III sec. 1, pt. IV, pt. VII-VIII.

147 *Id.* at pt. IX.

148 *Id.* at pt. XII.

149 *Id.* at pt. XIII.

150 *See* Pickens et al, *supra* note 138; Singh, *supra* note 143; 1994 Agreement, *supra* note 21, at Annex (Section 1)(15).

151 *See* Elizabeth Claire Alberts, *Deep-Sea Mining Rules Delayed Two More Years, Mining Start Remains Unclear*, Mongabay (July 2023), https://news.mongabay.com/2023/07/deep-sea-mining-rules-delayed-two-more-years-mining-start-remains-unclear/ [https://perma.cc/8V6E-HMH4]; *Deep Sea Conservation Coalition, No Deep-Sea Mining Approved as ISA Council Ends Despite Continued Push to Start a Failing Industry*, https://deep-sea-conservation.org/media-release-no-deep-sea-mining-approved-as-isa-council-ends-

exploitation, the ISA may be legally required to "consider and provisionally approve" that application despite the lack of regulations.[152] The ISA released a consolidated text of the draft regulations in February 2024. Negotiations will continue until the text is agreed upon with consensus.[153]

A private contractor sponsored by an ISA member State may apply for a mining concession in the Area.[154] UNCLOS defines contractors as "state enterprises or natural or juridical persons which possess the nationality of States Parties or are effectively controlled by them or their nationals."[155] Thus far, States have contracted with both private parties and through State enterprises.[156] States are responsible for ensuring through their domestic legal system that their contractors conform with the contract terms and with the obligations in part XI of UNCLOS on the Area—which includes provisions on deep-sea mining.[157] States are not liable for damage resulting from their contractors' failure to comply if States have "taken all necessary and appropriate measures to secure effective compliance" such as adopting domestic laws, regulations, and administrative procedures.[158] The sponsorship requirement ensures that obligations under the Convention, which is only binding on State parties, are also

despite-continued-push-to-start-a-failing-industry/ [https://perma.cc/BSB9-5U28] (last visited Oct. 10, 2025).

[152] *See* Singh, *supra* note 143; 1994 Agreement, *supra* note 21. Nauru is the sponsoring State of The Metals Company. The Metals Company, *NORI Project Overview*, https://metals.co/nori/ [https://perma.cc/6PBG-J47P] (last visited June 20, 2025).

[153] *See Statement by the President on the Work of the Council of the International Seabed Authority During the Second Part of the Twenty-Ninth Session*, INT'L SEABED AUTH., U.N. doc. ISBA/29/C/9/Add.1 (July 29, 2024), Annex III; Draft Regulations, *supra* note 31; Blanchard, et al., *supra* note 22.

[154] *See* UNCLOS, *supra* note 21, at art. 153(2); Alberto Pecoraro, *Law of the Sea and Investment Protection in Deep-Sea Mining*, 20 MELBOURNE J. INT'L L. (2024).

[155] *See* UNCLOS, *supra* note 21, at art. 153(2); Pecoraro, *supra* note 154.

[156] *See Exploration Contracts,* INT'L SEABED AUTH., https://www.isa.org.jm/exploration-contracts/ [https://perma.cc/X8B5-64AM] (last visited Sep. 9, 2025) [hereinafter Exploration Contracts].

[157] *See* UNCLOS, *supra* note 21, at art. 139(1), annex III art. 4(4).

[158] *See* UNCLOS, *supra* note 21, at art. 139(2).

mandatory for mining contractors through the domestic laws of their sponsoring States.[159]

The ISA reviews applications from contractors to explore deposits in areas designated for mining and awards portions of the deposits to successful applicants. The process to award exploitation contracts would be essentially the same.[160] So far, 31 exploration contracts have been issued to 22 contractors.[161] Under the draft regulations, the process to obtain a mineral exploitation contract is similar to that for mineral exploration contracts: Applicants submit a work plan for the proposed mining operation.[162] The work plans include environmental impact assessments (EIAs),[163] environmental management and monitoring plans,[164] and a closure plan to terminate and decommission the mining site.[165] The applicants must demonstrate their ability to mitigate environmental impacts and finance mitigation and remediation.[166] Areas of the seafloor under exploration will likely be the areas targeted for exploitation, but contracts for exploration do not translate into contracts for exploitation; applicants must submit new applications.[167] The ISA can only issue contracts to explore or exploit mineral deposits to mining contractors sponsored by States party to UNCLOS; private parties and States not party to UNCLOS cannot obtain contracts from the ISA.[168] Once exploitation regulations are finalized, or after the two-year rule is triggered, mining contractors sponsored by ISA member

159 *See* Responsibilities and Obligations of States sponsoring Persons and Entities with respect to Activities in the Area, Case No. 17, ITLOS (Seabed Dispute Chamber), Advisory Opinion (1 February 2011), para. 75 [hereinafter Responsibilities in the Area].

160 *See* Polymetallic Nodule Exploration Regulations, *supra* note 130; Polymetallic Sulphides Exploration Regulations, *supra* note 130; Ferromanganese Crusts Exploration Regulations, *supra* note 130; Draft Regulations, *supra* note 31.

161 *See* Exploration Contracts, *supra* note 156.

162 *See* Draft Regulations, *supra* note 31, at pt. II, Annex I.

163 *Id.* at Annex VI.

164 *Id.* at Annex VII.

165 *Id.* at Annex VIII.

166 *Id.* at Annex I, sec. III, IV(23), art. 26.

167 *Id.* at pt. II.

168 *See* UNCLOS, *supra* note 21, at art. 153(2)(b).

States will be able to apply for contracts to mine areas of the seafloor.[169] As of October 2025, no applications have been submitted.

2. The 1994 Implementation Agreement

Negotiations for UNCLOS were finalized in 1982 but the Convention was not immediately ratified, partially because the United States and other industrialized States expressed objections to provisions in part XI on the Area and the deep-sea mining regime.[170] The deep-sea mining regime articulated in part XI of UNCLOS focused on reducing inequities and opportunistic imbalances between developing and developed States by facilitating developing States' involvement in a deep-sea mining regime and redistributing financial and other economic benefits derived from deep sea mining.[171] The United States was concerned in particular that the deep sea mining regime articulated in part XI of UNCLOS could deter the development of deep-sea mineral resources and wanted a greater role in the decision making process and greater access to the resources.[172] The 1994 Implementation Agreement, which modifies part XI of UNCLOS in ways that are particularly favorable to the United States and other developed States, grew out of informal consultations by U.N. Secretary-General Javier Pérez de Cuéllar and his successor Boutros Boutros-Ghali to address these concerns and was intended to encourage widespread ratification of the Convention.[173]

The 1994 Implementation Agreement is a shift to a deep-sea mining regime more focused on commercial profits rather than on distributional justice.[174] Part XI of UNCLOS contains mechanisms

169 *Id*., at art. 153(2)(b), annex III, art. 3; Blanchard, et al., *supra* note 22; Singh, *supra* note 143.

170 *See* Bernard Oxman, *Law of the Sea Forum: The 1994 Agreement on Implementation of the Seabed Provisions of the Convention on the Law of the Sea*, 88 AJIL 687, 688 (1994); Moritaka Hayashi, *The 1994 Agreement for the Universalization of the Law of the Sea Convention*, 27 OCEAN DEV. & INT'L L. 31, 31 (1996). Despite the favorable provisions in the 1994 Implementation Agreement and the United States' involvement in negotiating both UNCLOS and the 1994 Implementation Agreement, the United States has not yet ratified the treaty.

171 *See* Isabel Feichtner, *Sharing the Riches of the Sea: The Redistributive and Fiscal Dimension of Deep Seabed Exploration*, 30 EUR. J. INT'L L. (2019).

172 *See* Oxman, *supra* note 170.

173 *Id.,* at 688.

174 *See* Feichtner, *supra* note 171.

to facilitate engagement by developing States in the deep-sea mining regime, such as through representation in decision-making and by reducing financial and technological barriers by requiring financial contributions and technology transfer from developed States to developing States.[175] The 1994 Implementation Agreement removes some of these mechanisms and replaces them with procedures that increase the power of the United States and other developed States at the ISA and favor free-market principles.[176] UNCLOS divided decision-making power between the Assembly—where each State has a single vote and developing States outnumber developed States—and the thirty-six-member Council elected by the Assembly (see figure 2).[177] The Convention also required decisions by the Council to be made via consensus, two-thirds, or three-quarters vote (depending on the topic) which, in the absence of veto powers, would have made it possible for developing States to outvote developed States due to their greater numbers.[178] The Agreement reduces developing States' power in the Council by enabling a majority in either four-member chamber of the Council (see figure 2 on the structure of the Council) to block votes by the Council.[179] It also curbs the Assembly's decision-making powers by requiring collaboration with the Council where developing States hold less power.[180] The Assembly's decision-making powers on matters with "financial and budgetary implications" are further curtailed by the requirement that they be "based on the recommendations of the Finance Committee" where major contributors to the ISA's

[175] *See id*.

[176] *See* Oxman, *supra* note 170; Allan G. Kirton & Stephen C. Vasciannie, *Deep Seabed Mining Under the Law of the Sea Convention and the Implementation Agreement: Developing Country Perspectives*, 51 SOC. & ECON. STUD. 63, 63 (2002).

[177] *See* Kirton & Vasciannie, *supra* note 176; *1994* Agreement, *supra* note 21, at Annex (Section 3)(15).

[178] *See* Oxman, *supra* note 170; Kirton & Vasciannie, *supra* note 176; UNCLOS, *supra* note 21, at art. 161(8)(b, c).

[179] *See* Oxman, *supra* note 170; Kirton & Vasciannie, *supra* note 176; 1994 Agreement, *supra* note 21, at Annex (Section 3)(5).

[180] *See* Kirton & Vasciannie, *supra* note 176; Oxman, *supra* note 170; 1994 Agreement, *supra* note 21, at Annex (Section 3)(4, 7).

administrative budget (i.e. developed States) have guaranteed seats.[181] The Agreement enhances the U.S.'s power at the ISA by guaranteeing it a seat on the Council in one of the four-member chambers with veto power.[182] Notably the U.S. has not ratified UNCLOS and thus has not taken up the seat. The Agreement gives a competitive advantage for developed States by removing production limits and limiting subsidies for deep-sea mining which benefits developed States capable of competitively mining and selling minerals on the global market but could harm developing States if they cannot do the same.[183] Land-based producers of deep-sea minerals, many of which are developing States, are also impacted by changes introduced by the Agreement which limits how much the ISA can compensate them for revenue lost due to competition from deep-sea mining—part XI of UNCLOS had empowered the ISA to provide compensation and other economic assistance.[184] Technology transfer from developed States to developing States, formerly required by part XI of UNCLOS, was severely curtailed; technology transfer is no longer required, forcing developing States to compete in the public markets for technology, which may not be cutting edge or up-to-date.[185] The Agreement also removed the requirement for all States to provide funding to the Enterprise to carry out deep-sea mining.[186] This reduces the financial burden on developed States but may make it difficult for the Enterprise to meet startup costs—and thus for developing States to engage in deep-sea mining through this organ.[187] These changes create a situation where mechanisms to reduce barriers for developing States are curtailed and developed States may be able to outcompete developing States.

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[181] *See* Kirton & Vasciannie, *supra* note 176; Oxman, *supra* note 170; 1994 Agreement, *supra* note 21, at Annex (Section 9)(3).

[182] *See* Oxman, *supra* note 170; 1994 Agreement, *supra* note 21, Annex (Section 3)(15(a)). The 1994 Implementation Agreement guarantees a seat to the State with the largest economy in terms of gross national product on the date that UNCLOS entered into force, which is the U.S.. The U.S. has not ratified UNCLOS and thus has never taken up that seat.

[183] *See* Kirton & Vasciannie, *supra* note 176, at 107; Oxman, *supra* note 170, at 694.

[184] *See* Kirton & Vasciannie, *supra* note 176, at 107.

[185] *Id*. at 103; Oxman, *supra* note 170, at 691.

[186] *See* Kirton & Vasciannie, *supra* note 176, at 95.

[187] *Id*., at 95.

The Agreement also removes potential regulatory obstacles and burdens that might slow down the deep-sea mining industry's growth.[188] These changes include making it easier to submit mining applications,[189] establishing the rule through which any State ready to submit an application to mine may trigger a two-year deadline to finalize exploitation regulations,[190] and making it more difficult than before to review and amend the Agreement.[191]

Obligations in part XI of UNCLOS to protect the marine environment are affirmed in the 1994 Implementation Agreement as is the status of the Area as the common heritage of humankind.[192] It articulates that between the Agreement's entry into force and approval of the first commercial mining operation, the ISA must focus on developing rules, regulations, and procedures focused on protecting the marine environment in a timely manner.[193] Additionally, the ISA must promote marine scientific research and technological development, with particular focus on the environmental impacts of activities in the area and acquire scientific knowledge and develop marine technology "relating to the protection and preservation of the marine environment."[194] States must also cooperate to promote this type of technology.[195] It articulates similar requirements for the Enterprise to be executed by the Secretariat on behalf of the Enterprise until the Enterprise is able to operate independently.[196] The 1994 Implementation Agreement also requires application for mining contracts to be accompanied by EIAs and proposed plans for baseline environmental studies.[197] The environmental requirements for mining contracts are further elaborated in the draft regulations,

188 Oxman, *supra* note 170.

189 *Id*.; 1994 Agreement, *supra* note 21, at Annex (Section 6)(7).

190 *See* Oxman, *supra* note 170; 1994 Agreement, *supra* note 21, at Annex (Section 1)(15). The two-year rule is explained in greater detail in Section IV of this Article.

191 *See* Oxman, *supra* note 170; 1994 Agreement, *supra* note 21, at Annex (Section 4).

192 *See* 1994 Agreement, *supra* note 21, at pmbl.

193 *Id*. at (Section 1)(5)(f, k).

194 *Id*. at (Section 1)(5)(h, i).

195 *Id*. at (Section 5)(1)(c).

196 *Id*. at (Section 2)(1)(b, d).

197 *Id*. at (Section 1)(7).

which contain additional requirements for environmental assessments, monitoring and management, and review.[198]

3. Obligations Under the United Nations Convention on the Law of the Sea

UNCLOS obligates States to protect the marine environment from the harms of deep-sea mining. Treaty provisions (1) mandate protection of the marine environment, (2) require States to have "reasonable regard" for other activities in the ocean, and (3) recognize the Area as part of the "common heritage of [hu]mankind."[199] We discuss these requirements in turn below. Current gaps in scientific knowledge thwart effective environmental management, may impact other industries using marine natural resources, and demonstrate that deep-sea mining may not be a good use of the global commons. We do not foreclose the possibility that new knowledge could reveal a way to bring deep-sea mining into compliance with the above obligations, but there are no indications that deep sea mining will ever be compatible with goals to protect marine biodiversity and ocean health.

a. Protecting the Marine Environment

Article 192 of UNCLOS obligates States to "protect and preserve the marine environment," an obligation that applies broadly to the global oceans.[200] The International Tribunal for the Law of the Sea (ITLOS)[201] concluded in its advisory opinion on climate change that article 192 of UNCLOS "imposes a general obligation on States Parties to protect and preserve the marine environment" and that this obligation "applies to all maritime areas and can be invoked to combat any form of degradation of the marine environment."[202] Article

198 *See* Draft Regulations, *supra* note 31, at sec. 2–3, reg. 11, pt. V, pt. VI.

199 UNCLOS, *supra* note 21, at arts. 145, 147(1), 147(3), pt. XII.

200 *Id*. at art. 192.

201 *Id*. at Annex VI, art. 1. The International Tribunal for the Law of the Sea is established in Annex VI, article 1 of UNCLOS.

202 *See* Request for an Advisory Opinion Submitted by the Commission of Small Island States on Climate Change and International Law, Case No. 31, Advisory Opinion (Int'l Trib. for the Law of the Sea, May 21, 2024), https://www.itlos.org/fileadmin/itlos/documents/cases/31/Advisory_Opinion/C31_Adv_Op_21.05.2024_orig.pdf [https://perma.cc/M35M-2Z26] [hereinafter ITLOS Climate Change].

145 of UNCLOS additionally requires States to "ensure effective protection of the marine environment from harmful effects" arising from activities in the Area.[203] Article 145 also requires States to take measures for "the prevention, reduction and control of pollution and other hazards to the marine environment" that may interfere with "the ecological balance of the marine environment" and "the protection and conservation of the natural resources of the Area and the prevention of damage to the flora and fauna of the marine environment."[204] This UNCLOS obligation to protect the marine environment[205] is linked to other obligations in the treaty such as the requirement to conduct EIAs,[206] the obligation to prevent transboundary harm,[207] and the duty to cooperate to prevent environmental harm.[208] Together, these obligations prescribe access to and use of the global marine commons by assigning obligations to States using these resources to limit harm to resources held in common.

Courts and tribunals have interpreted the obligation to protect the marine environment as conferring duties to act or refrain from acting in order to prevent harm.[209] The tribunal in the *South China Sea* arbitration clarified that States have an obligation to protect the marine environment from harm and concluded that the obligation is clarified by other provisions of UNCLOS (Part XII, Protection and Preservation of the Marine Environment) and rules of international law.[210] The tribunal further stated that the obligation "extends to both 'protection' of the marine environment from future damage and 'preservation' in the sense of maintaining or improving its present

203 UNCLOS, *supra* note 21, at art. 145.

204 *Id*. at art. 145.

205 *Id*. at pt. XII, art. 145.

206 *Id*. at art. 206.

207 *Id*. at art. 194(2).

208 *Id*. at art. 197.

209 *See* South China Sea Arbitration (Philippines. v. China), PCA Case No. 2013–19, Award (Perm. Ct. Arb. 2016); Southern Bluefin Tuna (New Zealand v. Japan, Australia v. Japan), Provisional Measures, Order of 27 August 1999, ITLOS Reports 1999 [hereinafter ITLOS Reports]. We explain the precautionary principle in greater detail subsequently; *see* discussion *infra* Part 3.A.iii.

210 *See* Phillipines. v. China, *supra* note 209, at para. 941.

condition."[211] Refraining from acting might involve not engaging in an activity that is likely to cause significant environmental harm or proceeding with precaution when an activity may cause harm—duties that are required by the no-harm and prevention principles of customary international environmental law.[212]

The tribunal in the *South China Sea* contextualized its interpretation of the obligation in article 192 to protect the marine environment with article 194 paragraph 5 concluding that when read together these articles require States to "take those measures 'necessary to protect and preserve rare or fragile ecosystems as well as the habitat of depleted, threatened or endangered species and other forms of marine life.'"[213] In its advisory opinion on climate change ITLOS also connected these two articles but noted that "[t]hese measures are context specific" and based on best available science.[214] Deep-sea ecosystems are rare and fragile and contain species that will likely be threatened and could be driven to extinction through habitat destruction caused by deep-sea mining; measures to protect and preserve these ecosystems are required by UNCLOS.[215]

In its advisory opinion on States' obligations and responsibilities in the Area, the Seabed Disputes Chamber stated that a "State must take into account, objectively, the relevant options in a manner that is reasonable, relevant and conducive to the benefit of mankind as a whole. It must act in good faith especially when its action is likely to affect prejudicially the interest of [hu]mankind as a whole."[216] In its advisory opinion on climate change ITLOS applied this interpretation to measures to protect and preserve the marine

211 *Id*.

212 *See* Dupuy & Viñuales, *supra* note 30.

213 *Id.* at para. 959 (quoting a letter from Dr. John W. McManus to the Tribunal dated Apr. 22, 2016).

214 *See* ITLOS Climate Change, *supra* note 202, para. 402–403, 405; UNCLOS, *supra* note 21, art. 192, 194(5). ITLOS found that article 194 paragraph 5 of UNCLOS obligates States "to protect and preserve rare or fragile ecosystems as well as the habitat of depleted, threatened or endangered species and other forms of marine life from climate change impacts and ocean acidification." ITLOS Climate Change, *supra* note 202, p. 152, Replies to Question (b) para. d.

215 *See* Levin et al, *supra* note 49; Niner et al., *supra* note 6; Drazen et al., *supra* note 36; Van Dover et al, *supra* note 44.

216 *See* Responsibilities in the Area, *supra* note 159, at para. 230.

environment from the impacts of climate change.[217] This obligation may apply to measures to prevent environmental damage from deep-sea mining as environmental damage from mining may impact the common heritage of humankind and may even impact communal high seas resources such as fisheries and other ecosystem services. The risk of environmental harm from deep-sea mining to communal resources affects the interests of humankind and requires "good faith" consideration of relevant options, including a moratorium.

b. The Seabed is the Common Heritage of Humankind

As the "common heritage of [hu]mankind," the Area and its mineral resources are owned by the global community.[218] Through ratifying UNCLOS, States party to the Convention have authorized the ISA to manage the seabed and subsoil of the Area.[219] As the Sri Lankan ambassador to the UNCLOS negotiations, M.C.W. Pinto, framed it, "[i]f you touch the nodules at the bottom of the sea, you touch my property. If you take them away, you take away my property. [T]he 'common heritage' of these resources . . . is more akin to property held in trust—held in trust for 'mankind as a whole.'"[220] As communal resources exploitation and exploration of the resources must also be "carried out for the benefit of [hu]mankind as a whole" with particular consideration of "the interests and needs of developing States," and peoples without "full independence or other self-governing status."[221]

The concept of the common heritage of humankind is rooted in the dilemma of how to manage commonly held resources that are

217 *See* ITLOS Climate Change, *supra* note 202, at para. 405.

218 *See* UNCLOS, *supra* note 21, at art. 136. Article 136 states that "The Area and its resources are common heritage of [hu]mankind."

219 *Id*. at preamble, arts. 137(2), 157(1); Rüdiger Wolfrum, *The Principle of the Common Heritage of Mankind* 81 HEIDELBERG J. INT'L L. 312 (1983).

220 *See* Scott Allen & John P. Craven, *Alternatives in Deepsea Mining*, 33 NAVAL WAR COLL. REV. 1 (1980), https://www.jstor.org/stable/44641996 [https://perma.cc/SYZ3-F6NB].

221 *See* UNCLOS, *supra* note 21, at preamble, art. 140(1). Article 140 paragraph 1 states that "Activities in the Area shall…be carried out for the benefit of [hu]mankind as a whole. . ." and proceeds to state ". . . taking into particular consideration the interests and needs of developing States and of peoples who have not attained full independence or other self-governing status recognized by the United Nations in accordance with General Assembly resolution 1514 (XV) and other relevant General Assembly resolutions."

vulnerable to overexploitation. Protection for the international seabed as a communal resource was championed by Professor Elisabeth Mann Borges and Malta's Ambassador to the UN, Arvid Pardo, and, in part, through their advocacy incorporated into UNCLOS.[222] However, the final formulation of the common heritage of humankind in UNCLOS is a compromise; a portion of the ocean was designated as held in common by humanity—the high seas and the Area—and a portion is under exclusive State control—the exclusive economic zones.[223] The incorporation of the common heritage of humankind into UNCLOS is part of a move toward international law that governs benefits only obtainable through international cooperation, in this case cooperation to collectively manage marine resources that could be easily overexploited by wealthy nations.[224]

The common heritage principle requires the resources in the Area to be managed for the benefit of all, rather than for those who can most efficiently exploit them.[225] Serious questions have been raised about whether deep-sea mining is capable of providing benefits to humankind that offset the potentially serious environmental costs.[226] Ecosystems in the Area provide services to humankind such as climate regulation by cycling nutrients, fisheries provisioning by providing habitat, and raw products for industrial and medical applications.[227] Inadequate ecological knowledge to evaluate

[222] *See* Richard Samuel Deese, *From World War to World Law: Elisabeth Mann Borgese and the Law of the Sea*, 32 WORLD HIST. BULL. 5, 5 (2016); *See* Michela Massimi, *The Fraught Legacy of the Common Heritage of Humankind Principle for Equitable Ocean Policy*, 153 ENV'T SCI. & POL'Y 103681 (2024).

[223] *See* Deese, *supra* note 222.

[224] *See* Alexandre Kiss, *The Common Heritage of Mankind: Utopia or Reality?*, 40 INT'L J. 423 (1985).

[225] *See* Dire Tladi, *The Common Heritage of Mankind and the Proposed Treaty on Biodiversity in Areas beyond National Jurisdiction: The Choice between Pragmatism and Sustainability*, 25 Y.B. INT'L ENV'T L. 113, 126 (2015); *See* Jeffrey Loan, *The Common Heritage of Mankind in Antarctica: An Analysis in Light of the Threats Posed by Climate Change*, 1 N.Z. YEARBOOK INT'L L. 1, 10 (2004) (available at http://www.nzlii.org/nz/journals/NZYbkIntLaw/2004/9.html) [https://perma.cc/F6DJ-ZXZC].

[226] Jaeckel, *supra* note 102 (discussing some tradeoffs between benefits and environmental costs).

[227] Jennifer T. Le, Lisa A. Levin, & Richard T. Carson, *Incorporating Ecosystem Services into Environmental Management of Deep-Seabed Mining*, DEEP-SEA RESEARCH II 137 (2017).

environmental costs—such as loss of ecosystem services—and benefits make it impossible critically evaluate the tradeoffs between mining or not mining. Preserving the resources by leaving them in place could benefit humanity through uninterrupted ecosystem services but extracting them could facilitate economic growth, combat climate change, and protect critical mineral security by fortifying supply chains. ISA member States must scrutinize and evaluate these tradeoffs, including environmental costs of deep-sea mining to humanity, in light of the communal nature of these resources, keeping in mind benefits for both present and future generations.[228]

UNCLOS requires the ISA to develop a benefit-sharing mechanism to help ensure that all States reap equitable financial benefits from deep-sea mineral exploitation.[229] Critics question the economic viability of benefit-sharing: profits from deep-sea mining may be minimal, so little money may flow into the fund, making mining a poor use of the global commons.[230] Others have raised concerns that the ISA's financial model centers profit for States and contractors engaged in mining over benefit sharing.[231] Further concerns have been raised over the ISA's economic model because it does not take into account the environmental costs of deep-sea mining to humankind.[232]

c. Reasonable or Due Regard for Other Activities in the Ocean: A Balancing Act

Article 87 of UNCLOS requires States operating on the high seas to have "due regard for the interests of other States in their

[228] *See* Joyner, *supra* note 20 (stating that serious scrutiny must be given to activities in the Area); *See* Massimi, *supra* note 222, at 2 (referencing the communal nature of the common heritage of humankind); Tladi, *supra* note 225, at 1274 (arguing that executing the common heritage principle requires environmental management to protect the common heritage for future generations).

[229] UNCLOS, *supra* note 21, at art. 140(2).

[230] *See* U. R. Sumaila, L. Alam, K. Pradhoshini, Temitope T. Onifade, Selma T. Karuaihe, P. Singh, Lisa A. Levin, R. Flint, *To Engage in Deep-Sea Mining or Not to Engage: What Do Full Net Cost Analyses Tell Us?*, 2 NPJ OCEAN SUSTAINABILITY (2023); Daniel Wilde, Hannah Lily, Neil Craik, Anindita Chakraborty, *Equitable Sharing of Deep-Sea Mining Benefits: More Questions Than Answers*, 151 MARINE POL'Y 1 (2023); Pickens et al., *supra* note 138. Estimates of financially regimes for deep-sea mining vary.

[231] Pickens et al., *supra* note 138.

[232] *Id*.

exercise of the freedom of the high seas" as well as "due regard for the rights under this Convention with respect to activities in the Area."[233] Article 147 of UNCLOS requires "[a]ctivities in the Area" to "be carried out with reasonable regard for other activities in the marine environment" and vice versa.[234] The terms "reasonable regard" and "due regard" are not defined in UNCLOS, but jurists have interpreted the terms to have the same meaning: an obligation on States to balance competing rights among States,[235] thus facilitating "coexistence between equally legitimate activities in a given maritime area."[236]

The arbitral tribunal in the 2015 case *Chagos Marine Protected Area Arbitration* (*Mauritius v. United Kingdom*) defined "due regard" as a balance between the rights of one State and those of another, taking into consideration the nature of the rights and activities.[237] In the Chagos Arbitration, the United Kingdom declared a no-take marine protected area around the Chagos archipelago, over which both the United Kingdom and Mauritius claimed sovereignty. The no-take area would have extinguished Mauritius's fishing rights around the archipelago.[238] Mauritius argued that this action was a violation of the due regard owed by the United Kingdom to Mauritius under UNCLOS and the Fish Stocks Agreement.[239] The tribunal found that by unilaterally establishing the marine protected area, the United Kingdom had not exercised due regard for Mauritius's right to be involved in decisions affecting future uses that would alter the territory when it was eventually returned to Mauritius.[240] The

233 UNCLOS, *supra* note 21, at art. 87(2).

234 *Id.* at art. 147(1,3).

235 *Id.* at arts. 87(2), 147(1,3); *see* Julia Gaunce, *On the Interpretation of the General Duty of "Due Regard"*, 32 OCEAN YEARBOOK 27, 56 (2018) (defining due regard as "an obligation on States to balance competing rights among States"); *see also supra*, note 22 (providing an explanation on the equivalency of the terms "due regard" and "reasonable regard").

236 Trullio Treves, *'Due Regard' Obligations under the 1982 UN Convention on the Law of the Sea: The Laying of Cables and Activities in the Area*, 34 INT. J. MAR. COAST. LAW (2019).

237 Chagos Marine Protected Area Arbitration (Mauritius v. U.K.), Case No. 2011-03, Award ¶ 519 (Perm. Ct. Arb. 2015) (Mar. 18, 2015).

238 *Id*.

239 *Id*.

240 *Id*. at para 520.

tribunal stated that when considering whether to proceed with an action that may affect the rights of another State, the State taking the action must consider factors such as "the nature [and importance] of the rights" that may be affected, the degree to which the rights might be affected, the "nature and importance of the activities," and available alternative actions.[241] The tribunal declined, however, to establish any universal rule of conduct.[242] In the 2012 case, *Delimitation of the Maritime Boundary between Bangladesh and Myanmar in the Bay of Bengal* (*Bangladesh v. Myanmar*), over Bangladesh and Myanmar's disputed Exclusive Economic Zone and Continental Shelf claims, the International Tribunal for the Law of the Sea (ITLOS) held that concurrent rights, such as multiple uses of the same area, require States to exercise "due regard" to the rights and duties of other States using the same area.[243]

Discussions between the submarine cable industry, some of which run through areas where mining may occur, and the ISA on how to balance these two marine activities are already occurring but have not yet been explored in the context of marine activities centered around the environment.[244] In the context of deep-sea mining, States engaged in mining might be required to have reasonable regard for the impacts that mining could have on other States' right to fish in the high seas, or reasonable regard for how it could alter the environment affecting other States' abilities to implement conservation measures or conduct certain types of scientific research (such as harvesting marine genetic resources). Knowledge of the extent of environmental impacts from deep-sea mining is critical for understanding how it may impact or impair environmentally centric marine activities and figuring out how to balance these activities with deep-sea mining. This evaluation is impossible so long as environmental impacts remain poorly understood.

241 *Id*. at para. 519.

242 Gaunce, *supra* note 235; Mauritius v. U.K., *supra* note 237, at para. 519; Philippines v. China, *supra* note 209.

243 Delimitation of the Maritime Boundary in the Bay of Bengal (Bangladesh v. Myanmar), Case No. 16, Judgment (Int'l Trib. L. of the Sea Mar. 14, 2012 at para. 475).

244 *See* Treves, *supra* note 236.

B. *International Environmental Law*

International law is shaped by treaties, "international custom, as evidence of a general practice accepted as law," general principles of law recognized by nations, and "judicial decisions and the teachings of the most highly qualified publicists."[245] International legal principles that have reached the level of customary practice—i.e. customary international law—are considered binding.[246] Two elements must exist for a custom or practice to become customary international law: (1) it must be generally practiced by States and (2) States must believe that the action is *opinio juris* (legally obligated).[247] The duty to prevent environmental harm and the duty to conduct environmental impact assessments are examples of customary international environmental law.[248] Principles that have not yet reached the status of customary international law, such as the precautionary approach or principle, which requires applying caution when an activity may cause serious and irreversible harm, and the due diligence standard of conduct can also impart compelling, but not binding, obligations on States.[249] Principles of customary international law and those that have not yet reached customary status can and should be considered and employed in designing the regulatory framework for deep-sea mining due to the serious risk of environmental impacts from deep-sea mining. We explain below how the due diligence standard of State conduct and closely linked prevention principle, the obligation to conduct EIAs, and the

[245] Statute of the International Court of Justice, art. 38, Oct. 24, 1945, 248 U.N.T.S. 33 [ICJ Statute].

[246] Dupuy, Le Moli, & Viñuales, *supra* note 20.

[247] Klabbers, *supra* note 20; International Law Commission, *Draft Conclusions on Identification of Customary International Law, with Commentaries*, United Nations, (2018); ICJ Statute, *supra* note 245, at art. 38.

[248] Dupuy, Le Moli, & Viñuales, *supra* note 20.

[249] Dupuy & Viñuales, *supra* note 30 (explaining that there is a debate over whether precaution is a binding principle of international law or if it is a nonbinding but guiding approach in situations where there is risk of irreversible environmental harm). In its advisory opinion on climate change the ICJ categorized the precautionary approach or principle under "Other principles" of law rather than as a "Customary international law" and stated that it guides the interpretation and application of other legal principles. Obligations of States in Respect of Climate Change, Case No. 187, ICJ, Advisory Opinion (23 July 2025), para. 146, 161 [hereinafter ICJ Climate Change].

precautionary principle or approach could be employed in the context of the legal and regulatory frameworks for deep-sea mining in the international seabed.

1. Due Diligence Standard

Due diligence is a standard of conduct to avoid environmental harm.[250] The standard overlaps with the duty to prevent environmental harm, because harm to the environment can be avoided or lessened by acting with due diligence.[251] However, the due diligence standard applies in all situations where there is risk of environmental harm[252] while the duty to prevent environmental harm is only triggered by the risk of significant environmental harm.[253] Due diligence requires States to take precautionary measures and conduct scientific risk assessments to "to assess the probability and seriousness of harm."[254] The standard also requires a level of excellency: diligent precautionary measures should take into account scientific and technological information, relevant rules, and international standards.[255]

As an obligation and standard of conduct due diligence requires States to act in ways that do the utmost to achieve the desired result.[256] However, States cannot be obligated to prevent harm but they are obligated to employ all reasonably available means to

250 Dupuy, Le Moli, & Viñuales, *supra* note 20.

251 ICJ Climate Change, *supra* note 249, at para. 280.

252 Dupuy, Le Moli, & Viñuales, *supra* note 20.

253 ICJ Climate Change, *supra* note 249, at para. 274 (citing: (Pulp Mills on the River Uruguay (Argentina v. Uruguay), Judgment, I.C.J. Reports 2010 (I), pp. 55–56, para. 101; Certain Activities Carried Out by Nicaragua in the Border Area (Costa Rica v. Nicaragua) and Construction of a Road in Costa Rica along the San Juan River (Nicaragua v. Costa Rica), Judgment, I.C.J. Reports 2015 (II), p. 711, para. 118, and p. 737, para. 217; Dispute over the Status and Use of the Waters of the Silala (Chile v. Bolivia), Judgment, I.C.J. Reports 2022 (II), p. 648, para. 99).

254 ICJ Climate Change, *supra* note 249, at para. 136, 283.

255 *Id*. at para. 136.

256 Responsibilities in the Area, *supra* note 159, at para. 110–111. The Seabed Disputes Chamber references the judgement in the *Pulp Mills on the River Uruguay* case in the advisory opinion to emphasize that the obligation of conduct is connected to the due diligence obligation saying that the Court called upon the parties to "exercise due diligence in acting through the [Uruguay River] Commission for the necessary measures to preserve the ecological balance of the river" para. 187 of the Judgement.

prevent harm as far as is possible.[257] Due diligence imparts an obligation "to take preventive or minimization measures" but it does not require "that significant harm be totally prevented, if it is not possible to do so", the State must "exert its best possible efforts to minimize the risk."[258] The due diligence standard also "has to be more severe for the riskier activities."[259] The standard will also be stricter where there is generally recognized scientific evidence showing that it is highly probable that severe harm will occur.[260] New evidence can increase the strictness of the principle.[261] Significant harm can be the result of cumulative environmental impacts rather than of just the activity under consideration.[262] This is important in the context of deep-sea mining as deep-sea ecosystems are experiencing cumulative impacts from climate change, over exploitation, and pollution.[263] Due diligence may require that these cumulative factors are considered holistically in the regulatory and management frameworks for deep-sea mining.

Monitoring and oversight may be necessary to fulfill due diligence obligations. In its judgement in *Gabčíkovo-Nagymaros Project* the ICJ pointed out that "in the field of environmental protection, vigilance and prevention are required on account of the often-irreversible character of damage to the environment and of the limitations inherent in the very mechanism of reparation of this type of damage."[264] Citing the ICJ's judgement in *Pulp Mills on the River Uruguay* the Seabed Disputes Chamber—a chamber of ITLOS[265]—

[257] ICJ Climate Change, *supra* note 249, at para. 135 (citing Application of the Convention on the Prevention and Punishment of the Crime of Genocide (Bosnia and Herzegovina v. Serbia and Montenegro), Judgment, I.C.J. Reports 2007 (I), p. 221, para. 430.

[258] Responsibilities in the Area, *supra* note 159, at para. 116 (citing International Olaw Commission Commentary to article 3 of its Articles on Prevention of Transboundary Harm from Hazardous Activities (2001)).

[259] Responsibilities in the Area, *supra* note 159, at para. 117.

[260] ICJ Climate Change, *supra* note 249, at para. 283.

[261] *Id*. at para. 284

[262] *Id*. at para. 276; ITLOS Climate Change, *supra* note 202, at para. 365.

[263] IPCC, *supra* note 2.

[264] Gabčíkovo-Nagymaros Project (Hungary/Slovakia), Judgment, I.C.J. Reports 1997, p. 78 at para. 140.

[265] ITLOS, Statute of the International Tribunal for the Law of the Sea, sec. 4.

points out in its advisory opinion on responsibilities and obligations in the Area that the due diligence standard requires both "the adoption of appropriate rules and measures" as well as "a certain level of vigilance in their enforcement and exercise of administrative control applicable to public and private operators, such as the monitoring of activities taken by such operators."[266]

This responsibility is particularly relevant where activities are primarily carried out by private actors.[267] Deep-sea mining activities are primarily carried out by contractors and sponsoring States have a due diligence obligation "to take all appropriate measures to prevent damage that might result from the activities of the contractors that they sponsor."[268] The Chamber explains that this due diligence obligation "applies in situations where scientific evidence concerning the scope and potential negative impact of the activity in question is insufficient but where there are plausible indications of potential risks."[269] Mounting evidence of environmental risks from deep-sea mining requires States to closely monitor mining contractors and take measures to prevent environmental damage caused by their contractors. The draft regulations permit a high degree of self-regulation and self-reporting which may be inadequate for effective oversight.

2. Environmental Impact Assessments

Environmental impact assessments assess and communicate the potential environmental and social risks of planned activities.[270] They identify the direct impacts of the proposed activity, evaluate alternative activities, anticipated impacts of alternative activities, and propose and evaluate potential mitigation measures.[271] An EIA occurs after baseline environmental data have been collected and

[266] Responsibilities in the Area, *supra* note 159, at para. 115 (citing Pulp Mills on the River Uruguay at para. 197).

[267] ICJ Climate Change, *supra* note 249, at para. 236.

[268] Responsibilities in the Area, *supra* note 159, at para. 131.

[269] Responsibilities in the Area, *supra* note 159, at para. 131.

[270] UNCLOS, *supra* note 21, art. 206; Jennifer M. Durden, Laura E. Lallier, Kevin Murphy, Aline Jaeckel, Kristina Gjerde, & Daniel O.B. Jones, *Environmental Impact Assessment Process for Deep-Sea Mining in the Area*, 87 MAR. POL'Y (2018).

[271] Durden et al., *supra* note 270.

once the project plan has been sufficiently developed that risks and mitigation options can be identified.[272] Information from EIAs can inform precautionary measures to prevent environmental degradation and States have a due diligence obligation to evaluate the risks associated with an activity by conducting an EIA.[273]

ITLOS states in its advisory opinion on climate change that the obligation to conduct EIAs is "crucial to ensure that activities do not harm the marine environment and is an essential part of a comprehensive environmental management system."[274] Environmental impact assessments (EIAs) are obligatory under both customary international law and article 206 of UNCLOS.[275] EIAs are a procedural obligation stemming from due diligence: to prevent "significant harm to the environment" States must undertake risk assessments, such as EIAs.[276] Although EIAs have typically been applied in the context of transboundary harm and shared resources, as in *Pulp Mills on the River Uruguay*, the Seabed Disputes Chamber has reasoned that the obligation could be applied to areas beyond national jurisdiction and resources that are the common heritage of humankind.[277]

Article 206 of UNCLOS sets a low threshold for triggering an EIA, a State must "have reasonable grounds for believing that planned activities under their jurisdiction or control may cause substantial pollution or significant and harmful changes to the marine environment."[278] Not only must a State carry out an EIA, it must also share the results with the competent international bodies.[279] In

[272] *See id*.

[273] *See id*.; ICJ Climate Change, *supra* note 249, at para. 296–7.

[274] ITLOS Climate Change, *supra* note 202, at para. 354 (citing Philippines. v. China, *supra* note 209, para. 948)

[275] Responsibilities in the Area, *supra* note 159, at para. 145.

[276] ICJ Climate Change, *supra* note 249, at para. 136, 295–7. The ICJ states that the requirement to conduct EIAs "is an expression of a more general rule requiring the assessment of risks to the environment." *Id*. at 297.

[277] Responsibilities in the Area, *supra* note 159, at para. 148 (referencing the Judgement in Pulp Mills on the River Uruguay and clarifying that although that Judgement was specific to the parties in the case, the Court's reasoning may apply to activities in areas beyond national jurisdiction).

[278] UNCLOS, *supra* note 21, at art. 206.

[279] Phil. v. China, *supra* note 209, at para. 991; UNCLOS, *supra* note 21, at art. 205.

the context of activities related to deep-sea mining in the Area, the sponsoring State has a due diligence obligation to make sure that their contractor is complying with the EIA obligation.[280]

ITLOS has determined that the broad wording of article 206 of UNCLOS does not preclude States from considering both the cumulative effects of planned activities and socio-economic impacts.[281] Cumulative impacts can result in significant environmental harm, and the due diligence standard is stricter when there is evidence that harm may be severe,[282] this suggests that EIAs may need to consider the proposed project in the context of cumulative environmental impacts such as other mining projects, climate change, biodiversity loss, and overexploitation. Although States are primarily responsible for determining the content and procedure of an EIA in their domestic legislation,[283] this likely does not preclude the draft regulations from requiring a more stringent procedure for mineral exploitation which could include holistic consideration of cumulative environmental impacts.

3. Precautionary Approach or Principle

The precautionary approach or principle states that if there is risk of irreparable environmental harm, measures to prevent that harm must not be delayed due to scientific uncertainty.[284] The risk of severe environmental harm and scientific uncertainty over the extent and severity of the harm require a precautionary approach to

[280] Responsibilities in the Area, *supra* note 159, at para. 141, 142.

[281] ITLOS Climate Change, *supra* note 202, at para. 365.

[282] ICJ Climate Change, *supra* note 249, at para. 283.

[283] ITLOS Climate Change, *supra* note 202, at para. 363 (citing Pulp Mills on the River Uruguay at para. 205).

[284] *See* Rio Declaration on Environment and Development, Principle 15, 13 June 1992, UN Doc. A/CONF.151/26.Rev.1 [hereinafter Rio Declaration] (stating that lack of scientific certainty is not a reason to delay measures to prevent environmental harm when there are threats of irreversible damage); Dupuy & Viñuales, *supra* note 30 (explaining the precautionary approach in greater detail). The modern formulation of the principle was famously stated in Article 15 of the 1992 Rio Declaration and has since appeared in other international environmental treaties such as the Fish Stocks Agreement, the BBNJ, and the United Nations Framework Convention on Climate Change. Rio Declaration, *supra* note 284; UNFSA, *supra* note 19, at art. 5(c); BBNJ, *supra* note 19, at art. 7(e); United Nations Framework Convention on Climate Change, Article 3(3), 9 May 1992, 31 ILM 849.

deep-sea mining. Although not yet customary international law,[285] application of the precautionary approach is a direct obligation of the sponsoring State,[286] and the norm may be trending towards customary international law status.[287]

The precautionary approach is "an integral part of the general obligation of due diligence of sponsoring States" which requires precautionary measures,[288] especially in instances of scientific uncertainty and serious environmental harm.[289] The due diligence standard requires sponsoring States "to take all appropriate measures to prevent damage that might result from the activities of the contractors they sponsor," including when scientific information is inadequate, as in the case in deep-sea mining.[290] The *Southern Bluefin Tuna Cases* link due diligence and the precautionary approach by declaring that the parties "should in the circumstances act with prudence and caution to ensure that conservation measures are taken."[291] The Tribunal stated that "although the tribunal cannot conclusively assess the scientific evidence presented by the parties, it finds that [management] measures should be taken as a matter of urgency,[292] despite scientific uncertainty over which measures should be taken to conserve southern bluefin tuna stocks.[293] Similarly, risk of severe harm and uncertainty over what measures could be taken to protect deep-sea ecosystems from deep-sea mining necessitate a precautionary approach to mineral exploitation.

A strong formulation of the approach would greatly restrict the proposed action while a weak formulation would impose minimal

[285] Dupuy, Le Moli, & Viñuales, *supra* note 20; Responsibilities in the Area, *supra* note 159, at para. 135.

[286] Responsibilities in the Area, *supra* note 159, at para. 122.

[287] Dupuy, Le Moli, & Viñuales, *supra* note 20; Responsibilities in the Area, *supra* note 159, at para. 135.

[288] ICJ Climate Change, *supra* note 249, at para. 136.

[289] Responsibilities in the Area, *supra* note 159, at para. 132; ITLOS Reports, *supra* note 209, at para. 77, 79.

[290] Responsibilities in the Area, *supra* note 159, at para. 131.

[291] *Id.* at para. 132.

[292] *Id*. at para. 132; ITLOS Reports, *supra* note 209, at para. 77.

[293] Responsibilities in the Area, *supra* note 159, at para. 132; ITLOS Reports, *supra* note 209, at para. 79.

restrictions.[294] Critics of the precautionary approach argue that strict application of the approach can be paralyzing, preventing development of new projects that could replace harmful alternatives currently in place.[295] Alternatively, weak applications of the precautionary approach fail to prevent new harms.[296]

The precautionary approach has been applied to issues around mineral exploitation, notably in the Convention on the Regulation of Antarctic Marine Resource Activities (CRAMRA), which regulated mining in the Antarctic.[297] CRAMRA applied an ecosystem-based management approach that prioritized preserving Antarctica's ecosystems over resource development and applied a series of decision-making tools, norms, principles, and rules to guide implementation.[298] The structure of CRAMRA was weighted in favor of the environment over resource extraction. This weighting was broadened when CRAMRA was replaced by the 1992 Madrid Protocol, which banned all mineral resource activities in Antarctica.[299] The moratorium has never been lifted because doing so requires a binding legal regime with an agreed-upon mechanism for determining if and how mining would be permitted in Antarctica.[300] The emphasis on ecosystem connectivity, data collection, cumulative impact assessments, independent review, the alternative of not proceeding, and the requirement for an agreed upon mechanism for permitting

[294] Russell Powell, *What's the Harm? An Evolutionary Theoretical Critique of the Precautionary Principle*, 20 KENNEDY INST. ETHICS J. 181 (2010) (explaining issues with how the precautionary principle has been formulated, applied, and thought about).

[295] Cass R. Sunstein, *Beyond the Precautionary Principle*, 151 UNIV. PA. LAW REV. 1003 (2003) (critiquing strong interpretations of the precautionary principle and pointing out issues with weak formulations of the principle).

[296] *Id*.

[297] *See* Nicolas R. Kirkham, Kristina M. Gjerde, A. Meriwether, & W. Wilson, *DEEP-SEA Mining: Policy Options to Preserve the Last Frontier - Lessons from Antarctica's Mineral Resource Convention*, 115 MARINE POL'Y 1 (2020) (explaining the legal framework governing mining in Antarctica); Convention on the Regulation of Antarctic Mineral Resource Activities, 2 June 1988, 27 ILM 868.

[298] Kirkham et al., *supra* note 297.

[299] *See id*.

[300] *See id*.; Protocol on Environmental Protection to the Antarctic Treaty, 4 October 1991, 30 ILM 1461.

mining could serve as a model for a similar precautionary decision-making framework for the mineral resources in the Area.[301]

III. CRITIQUE OF THE DRAFT EXPLOITATION REGULATIONS

In 2014 the Legal and Technical Commission of the ISA began developing the rules, regulations, and procedures for exploitation.[302] The fifth draft, released by the Legal and Technical Commission in 2024, is currently under negotiation by ISA member States.[303] The draft regulations purport to operationalize marine ecosystem protection through an "ecosystem-based management approach,"[304] considering "biological diversity" and "ecological integrity,"[305] and declare that, among other principles and approaches, application of the regulations shall be guided by the precautionary approach or principle,[306] "open access to non-confidential data and information,"[307] "transparency, inclusivity, and accountability in decision-making,"[308] and the use of "Best Available Scientific Information."[309] Work plans—submitted by the mining company in contract with a State—must include an Environmental Management and Monitoring Plan based on EIAs conducted prior to mining and based on "Best Available Scientific Evidence" and "Best Environmental Practices."[310]

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301 Kirkham et al., *supra* note 207.

302 Singh, *supra* note 143.

303 Draft Regulations, *supra* note 31.

304 *Id*. at reg. 2(4)(c).

305 *Id*. at reg. 2.

306 *Id*. at reg. 2(4)(b).

307 *Id*. at reg. 2(4)(e).

308 *Id*. at reg. 2(4)(f).

309 *Id*. at reg. 2(4)(g). "Best Available Scientific Information" is defined in the draft regulations as: "the scientific information and data accessible and attainable that, in the particular circumstances, is of good quality and is objective, within reasonable technical and economic constraints, and is based on internationally recognized scientific practices, standards, technologies and methodologies, including peer review. *Id*. at Schedule.

310 *Id*. at reg. 7(3)(h), 48, Annex VII. "Best Environmental Practices" is defined in the draft regulations as "the application of the most appropriate combination of environmental control measures and strategies, for purposes of ensuring the effective protection of the Marine Environment" and is a flexible standard based on

Finalization of the draft regulations has been delayed due to unresolved regulatory concerns, including on topics related to the environment. Delays are caused by insufficient time to negotiate the issues, divergent views among States, and insufficient information and input on the issues to inform negotiations—particularly information required to negotiate topics related to environmental management (although topics in finance and institutional governance also remain unresolved).[311] Outstanding regulatory issues related to the environment include issues related to baseline data, environmental thresholds, levels of permissible harm, monitoring, management, and establishment of a fund for environmental damage.[312] Relevant to enforcing environmental standards and management are outstanding issues in compliance, enforcement, and independent expertise.[313] Large informational inputs and careful regulatory design are critical for effective regulations. For example, if the "Best Available Scientific Evidence" is limited, even the most thorough management measures will be inherently incomplete. Gaps in baseline data for deep-sea environments and long-term impacts of mining on these complex ecosystems mean that any management or mitigation strategies will be based on an incomplete perspective of the environmental damage from mineral exploitation, making them ineffective. We will explore these challenges in detail in this section.

Momentum towards finalizing the draft regulations ramped up in 2021 when Nauru triggered the "two-year rule."[314] The two-year rule prevents indefinite delays in the regulatory process by requiring the ISA to adopt exploitation regulations within two years if requested by an ISA member State that intends to submit an application for mineral exploitation.[315] Nauru submitted such a request in 2021 however, the member States failed to reach the required consensus on a version of the draft regulations by the 2023 deadline and

"Best Available Scientific Information" and "Best Available Technology" (which is not defined in this draft of the Drat Regulations) that can change with improved "knowledge, understanding or technology" and also incorporates traditional indigenous knowledge and knowledge from local communities. *Id*. at Schedule.

311 Pickens et al., *supra* note 138.

312 *See id.*

313 *See id.*

314 Singh, *supra* note 143.

315 *See id*.

instead agreed to adopt draft regulations by July 2025, which passed without the adoption of draft regulations.[316] If regulations are not finished within the two years, the ISA may be required to evaluate, and provisionally approve, applications for exploitation based on provisions in UNCLOS, provisional rules, regulations, and procedures adopted by the Council, "norms contained in the convention and the terms and principles contained in this Annex as well as the principle of non-discrimination among contractors."[317] At the time of writing in November 2025 no mining applications have been submitted. The 1994 Implementation Agreement does not clarify what exactly provisional approval entails, whether it would need to be followed by a definitive approval after regulations are finalized, or whether mining could occur in the interim.[318] However, mining without regulations may contradict obligations under UNCLOS requiring the ISA to adopt regulations protecting the marine environment.[319] In line with this requirement, the ISA has adopted the position that exploitation should not be carried out without regulations.[320] If a contractor were to submit an application for

316 Elizabeth Claire Alberts, *Deep-Sea Mining Rules Delayed Two More Years, Mining Start Remains Unclear*, Mongabay (July 2023), https://news.mongabay.com/2023/07/deep-sea-mining-rules-delayed-two-more-years-mining-start-remains-unclear/ [https://perma.cc/66FR-DL2D]; Deep Sea Conservation Coalition, No Deep-Sea Mining Approved as ISA Council Ends Despite Continued Push to Start a Failing Industry, https://deep-sea-conservation.org/media-release-no-deep-sea-mining-approved-as-isa-council-ends-despite-continued-push-to-start-a-failing-industry/ [https://perma.cc/BR2P-JSQ5] (last visited Oct. 10, 2025).

317 Singh, *supra* note 143; Oxman, *supra* note 170; 1994 Agreement, *supra* note 21, Annex art. 15(c).

318 Klaas Willaert, *Under Pressure: The Impact of Invoking the Two Year Rule within the Context of Deep Sea Mining in the Area*, 36 INT'L J. MARINE & COASTAL L. 505 (2021).

319 UNCLOS, *supra* note 21, at art. 145; Singh, *supra* note 143; Oxman, *supra* note 170, at 692–93.

320 International Seabed Authority, Decision ISBA/28/C/9 (2023), https://www.isa.org.jm/wp-content/uploads/2023/04/2306127E.pdf [https://perma.cc/P6LZ-XH6A]; International Seabed Authority, Decision ISBA/28/C/24 (Jul. 21, 2023), https://www.isa.org.jm/wp-content/uploads/2023/07/2314552E.pdf [https://perma.cc/XKV7-8G2H]; International Seabed Authority, Decision ISBA/28/C/25 (Jul. 21, 2023), https://www.isa.org.jm/wp-content/uploads/2023/07/2314461E.pdf [https://perma.cc/XKV7-8G2H]; Willaert & Soete, *supra* note 99; In spring 2025 the president of the United States issued an executive order instructing the National

mineral exploitation before the draft regulations are finalized, the ISA would be forced to make a decision on how to apply the two-year rule and whether it must provisionally approve the application in the absence of exploitation regulations.[321]

The current draft regulations are impaired by a paucity of baseline data and thus cannot guarantee a high level of marine protection because they are based on inadequate scientific information and lack precise guidance for how to implement environmental protections.[322] Impaired management measures due to scarcity of

Oceanographic and Atmospheric Administration to issue permits for deep-sea mining in the Area and in United States waters under the Deep Seabed Hard Minerals Resources Act (DSHMRA), thus bypassing the ISA process entirely, further complicating the regulatory uncertainty around deep-sea mining. Trump Takes a Major Step Toward Seabed Mining in International Waters, N.Y. Times (April 24, 2025), https://www.nytimes.com/2025/04/24/climate/trump-seabed-mining.html?smid=nytcore-ios-share&referringSource=articleShare [https://perma.cc/9NUD-4N52]. In response the ISA has affirmed that as per UNCLOS Article 137 paragraph 1, no State may exercise sovereignty over the Area. International Seabed Authority, *Statement on the US Executive Order: 'Unleashing America's Offshore Critical Minerals and Resources'*, (April 30, 2025), https://www.isa.org.jm/news/statement-on-the-us-executive-order-unleashing-americas-offshore-critical-minerals-and-resources/ [https://perma.cc/X5BS-RP3W]. Shortly after the executive order was released The Metals Company submitted an application to NOAA for two mineral exploration permits and one commercial mineral exploitation permit in the Area. The Metals Company, *World First: TMC USA Submits Application for Commercial Recovery of Deep-Sea Minerals in the High Seas Under U.S. Seabed Mining Code*, (Apr. 29, 2025), https://investors.metals.co/news-releases/news-release-details/world-first-tmc-usa-submits-application-commercial-recovery-deep [https://perma.cc/93C4-JHKB]. The ISA may also investigate member States for non-compliance with UNCLOS and the 1994 Implementation Agreement if they participate in deep-sea mining in the Area before regulations are finalized. Max Bearak, *Seabed-Mining Firm Faces Legal Questions Over Controversial Trump Policy*, N.Y. Times (Jul, 21, 2025), https://www.nytimes.com/2025/07/21/climate/metals-company-seabed-mining-trump.html [https://perma.cc/QHR3-5M9M]. The United States is not a member of UNCLOS and thus cannot participate in deep-sea mining in the Area through the ISA, per UNCLOS Article 156 paragraph 2, ISA member States must be Parties to UNCLOS, which the United States is not. However, under UNCLOS the United States can conduct deep-sea mining in its own seabed. The United States does not agree with this view of the law, asserting that it has the legal right to also mine in the international seabed.

321 Singh, *supra* note 143; Willaert, *supra* note 318.

322 Giovanni Ardito, Marzia Rovere, *Racing the Clock: Recent Developments and Open Environmental Regulatory Issues at the International Seabed Authority on the Eve of Deep-Sea Mining*, MARINE POLICY 140 (2022).

environmental data prevents effective management and mitigation and could result in underfunded projects. Governance issues such as self-regulation and reporting by States and mining contractors would further weaken management measures by permitting management with little oversight and inadequate environmental information.[323] We identify four key areas of concern discussed in detail in the subsections below. First, the scarcity of baseline environmental data prevents identification of environmental thresholds which inhibits the development of management measures. Second, the proposed self-regulatory mechanisms in the draft regulations inhibit standardized environmental management and enforcement of high environmental standards by the ISA.[324] Third, inflexible regulatory mechanisms in the draft regulations further compound environmental damage from the dearth of baseline environmental data.[325] Fourth, measures to cover the financial costs of environmental damage may be similarly hindered by lack of robust environmental baselines, which would prevent accurate estimations of the financial costs of environmental damage and mitigation and management measures. This might mean that costs of covering monitoring and mitigation—as required by the draft regulations[326]—would be greater than the funds provided in advance by contractors, particularly if there are unforeseen environmental impacts; crucially, the ISA may not be able to cover these costs if contractors and contracting States are unable to.[327]

A. *Environmental Thresholds in the Current Draft Regulations*

Environmental thresholds are tipping points at which relatively small changes in environmental conditions trigger

[323] Ardito & Rovere, *supra* note 322.

[324] *See* Raphael Deberdt & Cara B.G. James, *Self-Governance at Depth: The International Seabed Authority and Verification Culture of the Deep-Sea Mining Industry*, RE. POL'Y 89 (2024).

[325] *See* Aline Jaeckel, *Deep Seabed Mining and Adaptive Management: The Procedural Challenges for the International Seabed Authority*, 70 MARINE POL'Y 205, 205 (2016).

[326] Draft Regulations, *supra* note 31, at reg. 13(2)(ii).

[327] Sumaila et al., *supra* note 230 (indicating that deep-sea mining may generate small profits); Draft Regulations, *supra* note 31, at pt. IV, sec. 6 (explaining the Environmental Compensation Fund).

disproportionately large or irreversible responses in ecological systems.[328] These represent boundaries between different states of ecosystem functioning—once crossed, the system may shift to a fundamentally different equilibrium that is difficult or impossible to reverse.[329] Thresholds are contingent on the combined biophysical responses of organisms in an ecosystem to a stressor (or stressors).[330] To properly manage deep-sea mining these tipping points must be understood. Lack of baseline environmental data prevents establishment of thresholds for evaluating or predicting ecological damage.[331] Knowledge about deep-sea ecosystems and organisms is not yet at a level where thresholds can be established with a high degree of accuracy and the scenario in which thresholds are established as mining is ongoing should be avoided, as it could result in severe, irreversible environmental degradation.[332]

Issues such as how to define permissible levels of environmental harm, establish thresholds for environmental harm, and how to collect enough baseline environmental data to establish robust baselines must be resolved before mining begins.[333] Thresholds for acceptable damage should be established before activities begin but are difficult to determine without baseline data on deep-sea ecosystems.[334] Thresholds from other ecosystems, such as from shallow water ecosystems or those developed for dredging and oil and gas offshore industries, can be applied to deep-sea mining but with limited applicability because deep-sea organisms have different biological responses than shallow water species.[335] Measures of disturbance to indicator species which foreshadow greater ecosystem

328 B. Hitchin, S. Smith, K. Kröger, D.O.B. Jones, A. Jaeckel, N.C. Mestre, J. Ardron, E. Escobar, J. van der Greint, & T. Amaro, *Thresholds in Deep-Seabed Mining: A Primer for their Development*, 149 MARINE POL'Y (2023).

329 Hitchin et al., *supra* note 328.

330 Ryan P. Kelly, Ashley L. Erickson, Lindley A. Mease, Willow Battista, John N. Kittinger, Rod Fujita, *Embracing Thresholds for Better Environmental Management*, PHIL. TRANSACTIONS ROYAL SOC'Y B: BIOLOGICAL SCIENCES 370 (2015), https://doi.org/10.1098/rstb.2013.0276 [https://perma.cc/46QN-N698].

331 *See* Ardito & Rovere, *supra* note 322; Hitchin et al., *supra* note 328.

332 *See* Amon et al., *supra* note 16.

333 *See* Pickens et al., *supra* note 138; Hitchin et al., *supra* note 328.

334 *See* Hitchin et al., *supra* note 328.

335 *See id*.; van der Grient & Drazen, *supra* note 66.

disturbance can be used to identify thresholds but limited ecological information prevents identification of indicator species.[336] Measures of change away from baselines can also be used as reference points, but comprehensive baselines have not been established for deep-sea ecosystems.[337] Further, data management issues in the DeepData database impair the accessibility and accuracy of this information for baseline scientific assessments.[338] Numerical models are another tool to establish baselines, however model quality depends on data availability—accuracy improves with more data.[339]

Scientific experts recommend improving data on affected ecosystems by leveraging scientific expertise to guide data collection and synthesis, analyzing existing data, and collecting more data.[340] Cohesive research agendas could be established through consultations with scientific experts at the outset to guide data collection and synthesis.[341] Unreleased non-confidential data collected by contractors could be released and added to existing global databases,[342] this would also help to avoid duplicating data collection efforts. Existing data that has not yet been synthesized should be synthesized to identify gaps that could be filled through additional analysis and data collection.[343] Leveraging existing datasets will improve analytical power and knowledge about affected ecosystems but more data must still be collected. In particular environmental and baseline data collection should be increased as should data collection on environmental impacts of deep-sea mining.[344]

A dearth of environmental data on which to establish baselines and environmental thresholds impairs both the environmental impact assessment conducted before the start of the project and monitoring during and after the project, which rely on these key

336 *See* Hitchin et al., *supra* note 328; Amon et al., *supra* note 16.

337 *See* Hitchin et al., *supra* note 328; Amon et al., *supra* note 16.

338 *See* Rabone et al., *supra* note 134; Amon et al., *supra* note 16.

339 *See* Hitchin et al., *supra* note 328; Amon et al., *supra* note 16.

340 *See* Amon et al., *supra* note 16.

341 *See id*.

342 *See id*.

343 *See id*.

344 *See id*.

informational inputs.[345] Baseline data collected prior to the EIA process are used to identify potential environmental impacts and mitigation measures that should be covered under the scope of the EIA.[346] However, the scarcity of environmental data complicate efforts to identify the scope of the EIA rendering it inadequate.[347] EIAs inform management needs and are used to develop mitigation and management plans so poorly scoped EIAs have consequences for all subsequent steps in the environmental management process.[348] Further, EIAs have historically proven inadequate for assessing complex environmental interactions and impacts.[349] Management plans ensure that environmental indicators stay below thresholds however, if thresholds cannot be identified or are poorly identified then management plans will be ineffective.[350] Effective management requires monitoring for signs that the ecosystem may be reaching tipping points during the mining operations and when mining operations have ceased. Without clearly defined thresholds and environmental indicators critical levels of environmental damage cannot be reliably identified.

Management should be adaptive and precautionary where there is uncertainty about the ecosystem response, as is the case when thresholds cannot be reliably identified.[351] As we will discuss in more detail, the draft regulations fail to assess and deploy accurate thresholds or leave room for changing regulations as scientific understanding of environmental thresholds develops.

Management of changing environments that are still being actively explored or quantified must be able to adapt to new information. Basing the ISA regulations on static, incomplete data would lock in a set of management standards that would not allow for

345 *See id*.

346 *See* Durden et al., *supra* note 270.

347 *See id*.

348 *See* Hitchin et al., *supra* note 328.

349 Malcolm R. Clark, Jennifer M. Durden, & Sabine Christiansen, *Environmental Impact Assessments for Deep-Sea Mining: Can We Improve Their Future Effectiveness?* 114 MARINE POL'Y 103363 (2020).

350 *See* Hitchin et al., *supra* note 328.

351 *See id*.

evolving ecological realities.[352] Environmental management and monitoring plans, deployed during mineral exploitation, will face information hurdles affecting their development so long as environmental parameters remain poorly defined.[353] Effective management requires that plans must be updated as thresholds are updated. This requires regulatory flexibility that is not yet adequately incorporated into the draft regulations, as we will discuss in subsequent sections.

B. *Self-Regulation Raises Concerns*

Compliance mechanisms are an important part of any governance regime. A compliance mechanism includes ways to monitor for compliance with the rules as well as take action for noncompliance. The mechanisms can take various forms. Multilateral environmental agreements often employ soft compliance mechanisms that promote compliance rather than punishing non-compliance.[354] These measures might include requiring parties to provide information on how they are implementing or complying with the treaty.[355] In some treaty systems, such as the Convention on International Trade in Endangered Species,[356] third-parties may be permitted to report on non-compliance.[357] Secretariates collect the compliance and implementation information and the veracity is assessed by smaller bodies with technical expertise.[358]

A governance regime for resource extraction requires appropriately tailored compliance mechanisms. The risk of serious

[352] Jaeckel, *supra* note 325 (discussing adaptive management in deep-sea mining). Adaptive management in the draft regulations is discussed in more depth in part C of this section.

[353] Pickens et al., *supra* note 138; Hitchin et al., *supra* note 328.

[354] Nils Goeteyn & Frank Maes, *Compliance Mechanisms in Multilateral Environmental Agreements: An Effective Way to Improve Compliance?*, 10 CHINESE J. INT'L L. (2011), https://doi.org/10.1093/chinesejil/jmr042 [https://perma.cc/9XX9-RAAN].

[355] *See id*.

[356] The Convention on International Trade in Endangered Species (CITES) regulates trade of wild animals and plants to ensure that trade does not threaten the survival of the species in the wild. Compliance mechanisms can be harsh; violators can be penalized through suspensions which prevent them from trading species listed in the treaty. Goeteyn & Maes, *supra* note 354.

[357] *See* Goeteyn & Maes, *supra* note 354.

[358] *See id*.

environmental harm and status of the mineral resources as the common heritage of humankind means that compliance mechanisms for deep-sea mining must be able to effectively ensure environmental protection and regulatory compliance. The draft regulations outline compliance mechanisms that have drawn criticism for relying too heavily on self-reporting by mining contractors.[359] Additionally, the draft regulations may prevent truly independent audits due to the small pool of experts capable of review, most of whom may have already worked for or alongside mining contractors.[360] Issues with auditing and compliance are further compounded by a dearth of established baselines on which thresholds for environmental harm can be built and access to the high quality data required for these analyses.[361] Baseline environmental data from DeepData can be used to conduct environmental evaluation, but the database's data management errors impair the usability of the information.[362]

Admittedly, although the current draft regulations have more substantial review mechanisms and contractors are subject to more oversight than in earlier drafts, enforcement is still largely self-imposed.[363] The draft regulations outline a self-regulatory process where deep-sea mining contractors are responsible for conducting their own baseline studies and EIAs, developing environmental management and monitoring plans, drafting their own work plans, and reporting compliance with the regulations.[364] The ISA reviews the work plans which contain the EIAs and environmental management and monitoring plans[365] and must consider the quality of baseline data upon which components of the work plan are based, but

359 *See* Deberdt & James, *supra* note 324.

360 *See id*.

361 *See id*.

362 *See* Rabone et al., *supra* note 134.

363 *See* Deberdt & James, *supra* note 324.

364 *See id*.; Draft Regulations, *supra* note 31, at reg. 7, 52.

365 Environmental management and monitoring plans contain, among other things, description of the project and areas of environmental impact, environmental thresholds and indicators, baseline data for the site, assessment of environmental effects their significance and uncertainties, description of the monitoring program, key thresholds and indicators that will be monitored, quality control and assessment methods for the management measures, a description of the monitoring system and technology and type and frequency of data collection. Draft Regulations, *supra* note 31, Annex VII.

the contractor is responsible for producing the documents and collecting the data. Experts are required to be involved in some steps of the process but are only required to be independent in some instances.[366]

The EIAs must be carried out by "competent experts" who are not required to be independent of the contractor, but the environmental impact statement (EIS), which contains the results of the assessment, is required to be assessed by independent scientific experts before submission to the ISA.[367] While the role of experts in conducting the EIA and the assessment of the EIS by independent scientific experts are important quality checks, these mechanisms do not resolve the underlying data scarcity issues. Poorly scoped EIAs, due to scarce environmental data,[368] means that EIAs will be inadequate for establishing environmental baselines and thresholds. Additionally, the lack of a requirement to employ independent experts to carry out the EIAs reenforces a self-regulatory structure.

An environmental management and monitoring plan is prepared by the contractor to manage the environmental effects predicted by the EIA.[369] ISA member States and stakeholders have the opportunity to review the environmental management and monitoring plan during the application process, but contractors are only required to "consider" feedback and not to incorporate or respond to feedback, indicating voluntary compliance and self-enforcement by the contractor.[370] The contractor is required to monitor the site during mineral exploitation for environmental effects.[371] The contractor is responsible for implementing the mitigation and management measures in the plan and monitoring compliance with the plan, assessing the plan's adequacy, and keeping the plan current.[372] On an annual basis the contractor must self-report on the plan's implementation, results, and their own compliance with the plan,[373] as is

366 Draft Regulations, *supra* note 31, at reg. 46(3)(b, e), 52(3).

367 *See id*. at reg. 46(3)(b, e).

368 *See* Durden et al., *supra* note 270.

369 *See* Draft Regulations, *supra* note 31, at reg. 50(1–2).

370 *See id.* at reg. 11(2 bis).

371 *See id*. at reg. 51(a).

372 *See id*. at reg. 51(d-e).

373 *See id*. at reg. 51(b-c).

common in environmental compliance mechanisms,[374] however data scarcity diminishes the utility of these reports. The contractor must conduct annual performance assessments of the plan and must hire an independent auditor for this task.[375] The Legal and Technical Commission reviews the performance assessments and if the commission finds that the contractor has not complied with the plan it may require the contractor to revise the plan or recommend that the compliance committee "consider" issuing a compliance notice under Regulation 103 which can be invoked when there is a breach of the terms and conditions of the exploitation contract by the contractor and requires remedial or corrective action.[376] The Legal and Technical Commission must rely on the contractor to develop and implement an adequate plan and reviews only the documents that the contractor provides. Although the independent auditor creates a degree of accountability on the contractor, this process largely relies on self-reporting by the contractor.

Other procedures in the draft regulations compound the self-regulatory process: Once mining operations have commenced, updates to the work plan, through which improved environmental standards could be incorporated, must be identified through periodic reviews carried out by the contractor and verified by an independent expert, indicating a process of partially voluntary self-enforcement by the contractor.[377] Further compounding the voluntary and self-enforced nature of environmental compliance in the draft regulations, mining operators are responsible during mining operations for informing the ISA if mining operations cause "[a]dverse environmental conditions with likely significant . . . environmental consequences" but can self-define those consequences.[378] Contractors are also tasked with preparing their own emergency response and contingency plans to respond to pollution and waste as well as with evaluating and reporting the adequacy of these plans.[379]

374 *See* Goeteyn & Maes, *supra* note 354.

375 *See* Draft Regulations, *supra* note 31, at regs. 52, 52(3), 52(9).

376 *See id*. reg. 52(8)(b), reg 103.

377 *See id.* at reg. 58, 58(2).

378 Deberdt & James, *supra* note 324; Draft Regulations, *supra* note 31, at reg. 34, app. I(10).

379 *See* Draft Regulations, *supra* note 31, at reg. 53.

Although self-regulation and reporting are less costly than external compliance enforcement while still permitting a degree of transparency, these mechanisms may weaken management measures by permitting key management decisions to be made with little oversight. This could result in weak environmental protections based on poorly defined environmental thresholds and inadequate EIAs due to data scarcity and limited participation by stakeholders and independent experts in the assessment process. Over time, these oversights could be further compounded by weak inspection and enforcement mechanisms, including a lack of independent mechanisms for verifying compliance, all of which indicate that the draft regulations would likely fail to protect marine ecosystems from environmental harm.[380]

C. *Inadequate Adaptive Environmental Management Measures*

Deep-sea mining requires adaptive management measures. In order to address the unpredictability of environmental impacts due to gaps in scientific information, environmental management measures must be able to be adjusted in response to new scientific information and advances in environmental management practices and technology.[381] An adaptive management approach is an iterative process in which small-scalereversible interventions are implemented following an experimental process in which they are monitored, information is collected, and outcomes are assessed.[382] The results are used to modify subsequent mining activities and inform and tailor management measures. While adaptability is necessary for environmental management, beginning deep-sea mining with the intent to later adapt management strategies introduces a scenario where irreversibly harmful practices are permitted in the meantime.[383] Maximizing adaptability is key to reducing irreversible

[380] *See* Ardito & Rovere, *supra* note 322, at 3–4; Deberdt & James, *supra* note 324, at 9, 11.

[381] *See* Daniel O.B. Jones, Jennifer M. Durden, Kevin Murphey, Kristina M. Gjerde, Aleksandra Gebicka, Ana Colaço, Telmo Morato, Daphne Cuvelier, & David S.M. Billet, *Existing Environmental Management Approaches Relevant to Deep-Sea Mining*, MARINE POL'Y 103 (2018)

[382] *See* Robert Makgill, Aline Jaeckel, & Keith MacMaster, IMPLEMENTING THE PRECAUTIONARY APPROACH FOR SEABED MINING: A REVIEW OF STATE PRACTICE 47 (Virginie Tassin Campanella ed., 2023); Jaeckel, *supra* note 325.

[383] *See* Jaeckel, *supra* note 325.

environmental consequences. The draft regulations are in many respects adaptable but key components remain inflexible, proceeding with mining without addressing these components heightens the risk of irreversible consequences.

Environmental risk management measures must be reevaluated as new information becomes available;[384] work plans must be periodically reviewed and updated as new scientific evidence or environmental risks and impacts are revealed;[385] environmental management and monitoring plans must be revised if they are inadequate to serve their purposes and or in light of new scientific information;[386] closure plans must also be kept up to date with information gained from implementing Environmental Monitoring and Management Plans and in accordance with Best Environmental Practices—which must also be updated as science and technology progress;[387] and the draft regulations must be reviewed every five years or at the request of a member State, the Commission, the Enterprise, a mining contractor, or a Stakeholder and may be amended in light of the review, but amendments do not apply to existing contracts.[388] UNCLOS guarantees security of tenure for contractors; modifications to the regulations would only apply to new contracts; and existing contracts can only be revised with the consent of all parties.[389] This calls into question the ability of the ISA to manage environmental impacts adaptively or even to respond to emerging environmental threats or new scientific information once commercial deep-sea mining has begun.[390] Contracts can be suspended or terminated in some instances, for example if the contractor violates the regulations.[391] However, determining if the contractor is violating environmental regulations would require monitoring and reporting. The self-regulatory mechanisms in the draft regulations suggest that

384 *See* Draft Regulations, *supra* note 31, at reg. 29.

385 *See id*. at reg. 58(1)(3).

386 *See id*. at reg. 52(1).

387 *See id*. at reg. 59(3).

388 *See id*. at reg. 107; UNCLOS, *supra* note 21, art. 153(6), Annex III arts. 18, 19. The amendment process must occur in accordance with UNCLOS and the Agreement.

389 *See* UNCLOS, *supra* note 21, art. 153(6), Annex III arts. 18, 19.

390 *See* Jaeckel, *supra* note 325.

391 *See* UNCLOS, *supra* note 21, Annex III art. 18.

monitoring and reporting may be inadequate to capture regulatory violations.[392] Workarounds to enhance adaptive management could include amending recommendations issued by the Legal and Technical Commission of the ISA that clarify and assist implementation of the regulations.[393] However, recommendations are non-binding, so States cannot be required to comply, making them a less ideal tool for adaptive management than the binding regulations.[394]

Adaptive measures are an important management strategy in situations where science and technology are rapidly advancing, as is the case in the deep-sea and for deep-sea mining.[395] However, adaptive measures are not designed to substitute or account for poorly informed projects; rather, they are meant to account for the dynamic nature of wild ecosystems and technological improvements in data collection over time. Management measures based on incomplete scientific information would lead to poor implementation which would then need to be fixed. Ultimately, poor implementation of these measures may fail to protect marine ecosystems by permitting harmful activity to proceed under the assumption that problems can be fixed later,[396] using adaptive measures that may not be adequate. This retroactive management is a weak formulation of the precautionary principle and is inadequate for true environmental protection compared to preventative management.[397] The possibility of serious irreversible harm to the environment and lack of scientific certainty requires a strong implementation of the precautionary approach. If mining is to be permitted at all, it should proceed cautiously through adaptive management measures that are reversible and closely monitored. Weakly implementing the precautionary principle by permitting large scale mining under the guise of adaptive management would permit poor environmental standards, which could result in severe environmental damage and misuse of the common heritage of humankind.

D. *Environmental Financial Assurances Require Robust*

392 *See* Deberdt & James, *supra* note 324.

393 *See* Jaeckel, *supra* note 325.

394 *See id*.

395 *See id*.

396 *See id*.

397 *See* Sunstein, *supra* note 295; Powell, *supra* note 294.

Environmental Information

Environmental financial assurances can be used to shift environmental costs onto the polluter, requiring the polluter to internalize the environmental impact of its activities by covering the financial cost of the damage.[398] This is a formulation of the polluter-pays principle in international law which shifts the burden of environmental costs onto the polluter.[399] Financial assurance mechanisms can take a variety of forms such as bonds, letters of credit, insurance, and trust funds but the purpose is the same: to guarantee that the polluter can cover the cost of environmental damage arising from their activities.[400] The amount is generally set by the regulator following an estimation of predicted environmental impacts.[401] The dependability of financial assurances as tools to cover environmental costs diminishes when environmental data is sparse. Without robust environmental data the magnitude of environmental damage and financial costs of counteracting such damage are less reliably predictable.[402] The high degree of environmental unknowns and unpredictable environmental impacts for deep-sea mining means that environmental guarantees may be inadequate to address the possible harms from deep-sea mining, shifting the burden of environmental damage from the polluting contractor to humankind.

The draft regulations employ two environmental financial assurance mechanisms: one to cover the environmental costs associated with closure and another to cover the cost of environmental damage if the contractor is insolvent.[403] The Environmental Performance Guarantee is a financial commitment submitted to the ISA before the start of commercial production and must cover the costs of premature closure of commercial activities, decommissioning and final closure of the mining site, and post-closure monitoring and

398 Jason Malone & Tim Winslow, *Financial Assurance: Environmental Protection as a Cost of Doing Business*, N. D. L, REV, 93 (2018), https://heinonline.org/HOL/Page?handle=hein.journals/nordak93&id=5 [https://perma.cc/D4S9-X5N6].

399 *See* Dupuy & Viñuales, *supra* note 30.

400 *See* Malone & Winslow, *supra* note 398.

401 *See id*.

402 *See id*. (discussing that predictability of environmental damage and financial costs improves with better data inputs).

403 *See* Draft Regulations, *supra* note 31, at reg. 26, 54.

management of environmental impacts.[404] The amount of the Environmental Performance Guarantee must be reviewed and updated on five year intervals, or if the closure plan is updated, if a performance assessment of the Environmental Management and Monitoring Plan requires the plan to be updated, if the work plan is updated, at least two years prior to the planned end of commercial production, or if the ISA determines that the costs of activities covered by the Environmental Performance Guarantee have increased.[405] The second environmental financial assurance mechanism is the Environmental Compensation Fund, funded in part by fees paid by contractors, is intended to cover the costs of unlawful environmental damage if the contractor is unable to.[406]

The environmental financial assurance mechanisms are intended to ensure that the cost of environmental damage is borne by the polluter, however sparse environmental data makes it impossible to predict the full extent of environmental damage and thus the nature, extent, and financial costs associated with counteracting environmental harm. Effective post-closure environmental monitoring and remediation requires (1) prior knowledge of undisturbed ecosystem function, (2) establishment of acceptable baselines for environmental harm using pre-mining environmental baselines, (3) repeated and standardized monitoring over a meaningful period of time, (4) reliable reporting, and (5) implementation of proven remediation techniques. Without adequate environmental data monitoring needs cannot be reliably predicted and appropriate management measures cannot be established, making it impossible to accurately predict the cost of post-mining monitoring and management. Unexpected environmental impacts may require greater spending on remediation and additional financing may be unavailable. The financial unpredictability increases the likelihood that contractors may be unable to cover costs and the possibility that they will default on their environmental obligations. Deep-sea mining may be too unpredictable for effective financial assurance mechanisms which may be better suited for projects with fewer environmental unknowns.

404 *See id*. at reg. 26(1–2).

405 *See id*. at reg. 26(4).

406 *See id*. at reg. 55.

CONCLUSION

Deep-sea mining is likely to be environmentally devastating, triggering obligations under international environmental and ocean law to prevent harm to the marine environment. To comply with obligations under international law, mining regulations would need to minimize biodiversity loss and ecological damage, something that is not possible given the paucity of data on both affected ecosystems and environmental impacts from deep-sea mining. This necessitates a moratorium until knowledge improves to the point that serious and irreversible environmental impacts can be confidently avoided or minimized. Significant gaps in scientific knowledge, particularly about deep-sea and pelagic ecosystems, make it impossible to anticipate and respond to ecological impacts from deep-sea mining, rendering the draft regulations inadequate to prevent serious environmental harm and requiring a moratorium to comply with obligations of international environmental law.

Gaps in essential environmental knowledge about affected ecosystems and possible environmental impacts mean that it is impossible to mine the deep-sea while complying with obligations under international environmental law.[407] Obligations under UNCLOS to protect the marine environment require effective environmental management and mitigation measures—which require additional informational inputs not yet available due to the dearth of environmental data.[408] The extraction of and environmental impacts on communal resources in the Area require an evaluation of whether or not deep-sea mining is an appropriate use of the common heritage of [hu]mankind, but this is impossible to evaluate with only sparse information on the environmental impacts from deep-sea mining and ecosystem services provided by impacted ecosystems.[409]

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[407] *See* Zachary Douglas, Taulupapa Brenda Heather-Latu, Toby Fisher, & Jessica Jones, *In the Matter of a Proposed Moratorium or Precautionary Pause On Deep-Sea Mining Beyond National Jurisdiction*, PEW (2023), para. 133–36 (explaining that UNCLOS and international law require States to "cooperate to ensure that exploitation of the Area does not proceed unless it can be carried out without risking significant harm to the marine environment[,]" something that cannot be done in the absence of data which could be used to establish environmental baselines against which the environmental impacts of deep-sea mining could be compared).

[408] *See* UNCLOS, *supra* note 21, at art. 145, pt. XII.

[409] *See id.* at art. 140.

Further complicating this analysis is a lack of clarity on the financial and economic profitability of deep-sea mining which calls into question whether the activity will generate financial benefits for humankind as required by UNCLOS.[410] The possibility of environmental harm that may impact concurrent activities such as fishing in the high seas and marine scientific research requires deep-sea mining to be balanced with these activities, but sparse environmental data similarly impairs this evaluation and thus compliance with the reasonable regard requirement in UNCLOS.[411]

Scientific uncertainty as to the magnitude and spatiotemporal scale of environmental impacts combined with the risk of serious environmental harm necessitate a precautionary approach to deep-sea mining.[412] However, inadequate data hinders precautionary measures. The due diligence obligation to take precautionary measures to prevent environmental damage is strict for deep-sea mining due to scientific evidence that environmental harm will occur and the riskiness of the activity, however measures to prevent environmental harm are ineffective without adequate data.[413] EIAs—which inform precautionary measures—are insufficient to identify potential impacts without adequate environmental data to inform the scope.[414] A moratorium may be necessary to prevent serious environmental harm since the dearth of environmental information renders other precautionary measures ineffective to prevent serious environmental harm.

The environmental regulations in the draft regulations are hindered by sparse environmental data and unable to prevent serious environmental damage. The draft regulations do not contain functional formulations of precautionary management measures since the lack of baseline data upon which to establish thresholds impairs management actions. The combination of sparse environmental data

410 *See id*.

411 *See id*. at art. 147.

412 *See* ALINE L. JAECKEL, THE INTERNATIONAL SEABED AUTHORITY AND THE PRECAUTIONARY PRINCIPLE: BALANCING DEEP SEABED MINERAL MINING AND MARINE ENVIRONMENTAL PROTECTION (2017).

413 *See* Responsibilities in the Area, *supra* note 159, at para. 117; ICJ Climate Change, *supra* note 249, at para. 283.

414 *See* Responsibilities in the Area, *supra* note 159, at para. 145; UNCLOS, *supra* note 21, at art. 206; Durden et al., *supra* note 270.

to inform decision-making and self-regulation may result in ineffective environmental protections. Moreover, adaptive management measures cannot be implemented with enough regulatory flexibility to be truly adaptive.[415] Finally, financial assurances may be inadequate due to unknowns about the economic costs of environmental damage that cannot be answered without more environmental data. Although the draft regulations require the application of the precautionary approach as appropriate with respect to the marine environment,[416] precautionary measures other than a moratorium may be ineffective to prevent environmental harm due to the lack of essential environmental data.

Deep-sea mining has the potential to cause significant, permanent harm to marine ecosystems and ecological restoration may be impossible.[417] Marine biodiversity is essential for maintaining healthy ecosystems which provide critical economic, health, atmospheric, and food services to the entire planet.[418] With biodiversity in crisis, effective and long-term marine resource management and biodiversity protection is essential to sustain ecosystems.[419] Deep-sea mining would stress ecosystems already suffering from other anthropogenic impacts, such as climate change and overexploitation, making them less resilient to environmental stressors and exacerbating biodiversity loss. Due to the potential for significant and permanent harm to marine ecosystems and biodiversity from deep-sea mining, international environmental and ocean law require a moratorium on deep-sea mining until enough scientific information is available to avoid serious environmental harm.

415 *See* Jaeckel, *supra* note 325.

416 *See* Draft Regulations *supra* note 31, at reg. 44(a) (regulation 44 identifies general obligations related to the marine environment).

417 *See* Niner et al., *supra* note 6; Sumaila, et al., *supra* note 230; Tunnicliffe, *supra* note 10 (stating that ecological restoration in the deep-sea is impossible).

418 *See* Worm et al., *supra* note 4.

419 *See id*.