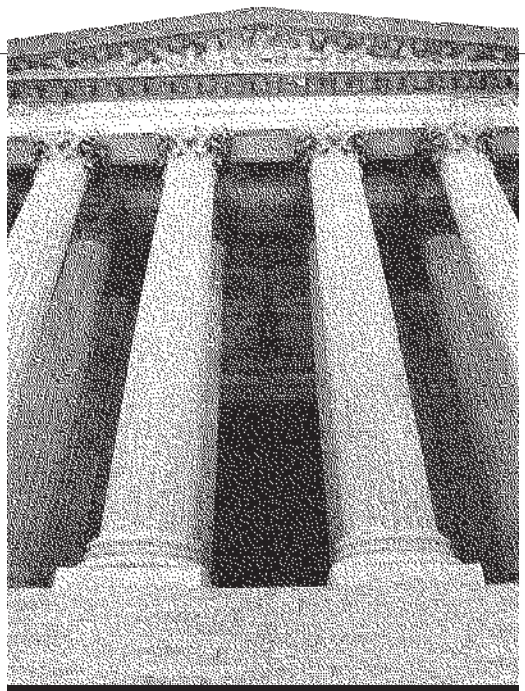

THE DEBATE

Years After Treaty Goes Into Force, Mining on the Seafloor Ratchets Up

The issue of deep seabed mining, how to manage it, and who benefits from it was a topic of intense debate during the lengthy period of negotiations to develop the United Nations Convention on the Law of the Sea in the 1970s and 1980s. It is still a topic of heated concern, which is why here we present a cluster of articles on seafloor mining in advance of the July meeting of the instrumentality created by UNCLOS, the International Seabed Authority.

While there was a widely held belief at the time of negotiation of UNCLOS as to the promise of wealth contained within the seabed, the cost and difficulty of operating in the abyss long kept mining at bay. In the first decades following the adoption of the treaty, the topic of the international seabed drifted into relative obscurity. Today, however, a growing number of prospectors are obtaining exploration leases with the goal of achieving commercial-scale exploitation of areas as large as medium-sized countries.

This deep seabed mining could disrupt sensitive ecosystems that we know little about and lead to wide-scale pollution of the adjacent ocean waters and the deep ocean floor. It could also lead to abundant sources of now-rare minerals useful in the digital economy, space exploration, energy generation and transmission, manufacturing, and industry in general, benefitting many in mining companies, their customers, and society as a whole.

To keep pace with commercial and national interests in seabed exploitation, ISA was tasked with regulating the ocean floor beyond national jurisdiction. Now it is under pressure to develop an appropriate Mining Code for the deep seabed "Area." Already ISA has issued regulations for exploration, as well as exploration permits, for huge swaths of the deep seabed. It now faces the daunting task of developing rules for exploitation; ISA has issued a draft working paper that includes draft environmental regulations.

At issue is decisionmaking regarding extraction as well as development of national standards for seabed mining. While these activities will take place far from shore and from communities, the effects could be wide-ranging, with impacts in some places like the abyssal plains essentially irreversible in human timescales and affecting huge regions, with potential spillovers impacting onshore society.

How will this process be managed in a responsible way, to reap the benefits for society while preserving the seafloor ecological community and minimizing pollution of ocean waters? Can an international institution help nations and mining companies exploit these resources in a sustainable manner?

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Kristina Maria Gjerde
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"Mining will be the greatest assault on deep-sea ecosystems ever inflicted by humans."

Verena Tunnicliffe
Canada Research Chair in Deep Oceans
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With Mining on Horizon, Time to Ask, Ready or Not?

By Kristina Maria Gjerde

The UN Convention on the Law of the Sea provides a firm foundation for regulating seabed mining. The challenge confronting us today lies in developing and effectively implementing rules, standards, and principles requiring environmental protection.

UNCLOS and its 1994 Implementing Agreement designate the Area and its mineral resources as the "common heritage of mankind" and charge the International Seabed Authority with acting on behalf of "mankind as a whole." From an environmental perspective, UNCLOS sets forth strong obligations for the development of rules, regulations, and procedures to "ensure the effective protection of the marine environment from the harmful effects of seabed mining." All mineral exploration and exploitation activities must be sponsored by a state party to UNCLOS; ISA is to secure compliance. Financial and other economic benefits from seabed mining are subject to equitable sharing under rules still to be developed by ISA.

However, these provisions of UNCLOS were drafted in the late 1970s, before much was known about the deep sea environment or the potential consequences of seabed mining. Chemo-synthetic life was not even known then. Instead of easy pickings of potato-sized nodules from a largely lifeless seafloor, recent scientific studies have revealed that areas of the abyssal plain may be as rich in biodiversity as tropical rainforests. One study carried out as part of the EC-funded MIDAS project revealed that the nodules in the Clarion Clipperton Zone provide essential habitat for many different types of marine life, including intertwined sponges, sea lilies, and egg-nurturing octopuses. The study also found that there was virtually no recovery in trawl tracks and experimental mining simulations carried out 37 years ago. Other studies have confirmed that direct mining impacts, other than perhaps in regions with fast-growing hydrothermal vents, will be long lasting, and plumes extensive. Yet, impacts on the deep ocean water column, the largest habitat for life on Earth, remain virtually unstudied. Questions thus have to be raised as to whether we really need these new sources of minerals now, and whether it might be better to focus on re-using and recycling our present stockpiles, developing a circular economy, and cleaning up mining practices on land before turning to the sea.

What does this mean for the future of seabed mining? It means that, consistent with the precautionary principle, mining should not take place until more is understood about deep-sea ecosystems. We should focus first on studying deep ocean ecosystem processes, structures and functions and their contribution to ecosystem services that benefit all of humankind. If mining is permitted it should start small and only expand once monitoring and observations have confirmed that mining will not disrupt long-term ecosystem well-being.

It means that the environmental regulations now under development should include a wide range of ecological safeguards. First, the vast majority of the seabed should be set off-limits to mining. Second, resources with lower risks in a limited number of small sites should be first exploited to facilitate in-situ learning. Only then should it be decided whether or not to continue exploiting and to exploit in other areas. Third, requirements need to be in place to ensure high-quality baseline data, environmental impact assessments, site-specific environmental controls, and long-term management and monitoring plans. Fourth, regional-scale environmental assessments and plans should be developed that set aside a significant percentage of representative areas, corridors, and special features permanently. Fifth, mining regulations should identify and incorporate thresholds and triggers to, inter alia, indicate a potential for serious harm, in order to enable ISA to take pre-emptive action to prevent such harm. Finally, funding for research should be scaled up.

How can the nations of the world access the considerable resources of the deep seabed responsibly? Deep seabed mining is a new frontier, and for once we have the chance to get it right. In line with the common heritage of mankind principle, transparent, clear, and effective procedures must be in place to ensure public participation and accountability at all stages.

There should be a presumption that information generated in the Area is non-confidential unless otherwise determined, and meetings of ISA's Legal and Technical Commission should be open to observers other than when necessary to protect proprietary information or to ensure the independence of commission members. The public should be informed and engaged, in particular in value-based decisions regarding the risks, benefits, and alternatives of seabed mining, the value of marine ecosystems and their ecosystem services, and the sharing of benefits intra-generationally and inter-generationally. An environmental commission should be established; this was an omission when UNCLOS was negotiated.

Rather than allowing the uncertain promise of economic benefits to seduce countries to lurch too quickly into mining activities, we would be wise to look before we leap. We should consider what the potential payback is to society, in particular to developing countries. We should consider what sort of long-term economic benefits might be expected for society and whether these can compensate for potentially irreversible harm and loss of essential if poorly understood ecosystem services.

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An Opportunity to Perfect Lessons From the Past

By Renée Grogan

Deep-sea mining, if regulated tightly, carried out responsibly, and monitored transparently, has the potential to unlock vast mineral deposits in a resource-hungry world, in a more sustainable manner than terrestrial mining has historically been. And let's not beat about the bush here: the world is hungry for minerals. If we are serious about feeding, housing, communicating with and developing the world, mining is inevitable. To really consider the best and most sustainable options, seafloor mining has to be on the table.

With a foot in both domestic legislation and international regulation under the UN Convention on the Law of the Sea, seafloor mining presents the opportunity to change the game of environmental management in extractive industries. Domestic governments, as well as the International Seabed Authority, have an opportunity to heavily scrutinize the history of environmental management in terrestrial mining, oil and gas extraction, and dredging.

In the international arena, UNCLOS provides the foundation for the development of a regulatory framework for seabed mining. It is the task of ISA to prescribe regulations for the exploitation of minerals on the seabed, including environmental regulations. To do this, ISA must identify the environmental management best practices and regulatory features from the history books, make any adjustments to account for the unique environment of the deep sea, and ensure the product fits snugly within the framework of the UNCLOS treaty.

To achieve best practices, there are essential requirements at the three stages of mining: permitting or approvals; operations; and closure.

A transparent approach to permitting, involving the preparation of an environmental impact assessment in accordance with an agreed scope, should address all the environmental aspects, impacts, risks, and opportunities associated with the project. Key impacts should be considered as a range of possible outcomes, rather than a single prediction, given the uncertainty of operating conditions. License or permit conditions that are outcome based, rather than management based, should be implemented, allowing contractors flexibility to adapt management practices on the basis of monitoring.

Commitments in relation to environmental outcomes should be specific, measurable, achievable, and time bound. EIA documents should be made publicly available as part of the stakeholder engagement process. Most importantly, a level playing field must be maintained so that all nations are required to meet the same level of environmental rigor and protection.

Environmental management plans should be developed ahead of operations, and provided to ISA (or other regulatory body, in domestic circumstances) for approval. These documents should include operational monitoring plans and management commitments for each environmental aspect, and should be amended on a regular basis to reflect adaptive management and continuous improvement. Monitoring strategies should report on performance against commitments in the EIA and license or permit conditions, as well as on ongoing trends in environmental data. Regular and transparent reporting of data should be required of all contractors, and publicly available to the wider stakeholder group.

The regulatory body absolutely must implement a compliance and enforcement process that holds industry players accountable for performance. Given the remote location of many deep sea mineral deposits, there will be logistical and financial challenges associated with auditing and inspecting these operations. However, the oil and gas industry can provide some context on overcoming these obstacles, and robust self-regulation (including peer review of monitoring data) is also a powerful tool.

Closure plans should be developed as part of the EIA process, and should reflect agreed objectives and targets, such as the reestablishment of functioning ecosystems. Monitoring of post-mining recovery and (if relevant) rehabilitation should be transparent and frequent, so that lessons can be learned and adjustments in management strategies and regulations made for future operations.

Transparent reporting of performance against objectives and license/permit/contract conditions will be essential — all parties need to be accountable for their performance to ensure that the industry does not adopt an out-of-sight, out-of-mind approach. If adequate environmental management, impact mitigation, and closure strategies are not possible (as evidenced by the EIA), or not achieved during operation, the "no mine" option should be the regulatory outcome. By communicating this possibility to industry players and stakeholders alike, the stick very much accompanies the carrot.

Finally, capacity building is an essential part of this journey. The world of deep-sea mining requires very specific scientific, engineering, management, and processing capabilities. Improving these capabilities in both developing and developed nations will undoubtedly unlock potential for continuous improvement in the sustainable access of deep sea resources into the future.

Renée Grogan is a director of the World Ocean Council, a global, cross-sectoral ocean industry alliance committed to corporate ocean responsibility

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Policy Decisions Present ISA's Biggest Challenge

By Hannah Lily

The architects of the UN Convention on the Law of the Sea agonized over how to treat the deep-sea mineral resources of the international seabed — known as the Area. A key concern was to avoid a gold-rush scenario where technologically advanced countries would be able to mine and reap benefits before poorer nations. UNCLOS sought to address this problem by prioritizing the involvement of developing states and, radically, proclaiming "the resources of the Area" as "the common heritage of mankind." So the natural resources in the Area belong to all of us! What does this really mean, in the context of current international discussions about regulations for potential world-first deep-sea mining projects?

UNCLOS straddles a central tension between protecting the marine environment, while recognizing humankind's desire to exploit resources for development and economic purposes. This balancing act remains current today, as reflected in the UN's Sustainable Development Goal 14, to "conserve and sustainably use the oceans, seas, and marine resources."

It falls to the International Seabed Authority to operationalize this tension in relation to deep-sea minerals in international waters. ISA is tasked by UNCLOS to "ensure the development of the resources of the Area" and yet also to "ensure effective protection for the marine environment." And ISA must do this "for the benefit of mankind as a whole"? A tough task.

UNCLOS's description of ISA's dual role implies that mining should only occur in circumstances where it will yield significant economic benefit to developing country nationals, and where the environmental impact can be predicted and minimized to an acceptable level. What constitutes "significant" and "acceptable" must be supported by evidence, and enshrined by scientific and legal criteria. Clear and stringent rules will be essential here. ISA is working on a raft of new regulations currently, covering licensing, environmental management, and the financial regime for mining in the Area.

But even with best-practice regulations in place, the threshold for an "acceptable" level of environmental harm ultimately comes down to a value judgment. Recent years have seen increasing environmental law emphasis on public participation in value-based decisions. Such an approach fits well with a modern interpretation of the "common heritage of mankind," but heightens the challenge faced by ISA in fulfilling its duty to represent current and future humankind.

ISA is an intergovernmental organization and its decisions are taken by the 168 governments that are party to UNCLOS. This should give confidence that such decisions will be made with global oversight, and with interested groups able to exert influence through democratic processes. In practice, fewer than half of the UNCLOS member states attend ISA's annual meetings, and representation is often strongest from countries who are invested in deep-sea mining.

Some recent developments are positive. ISA underwent an external review process last year, seeking to improve practices. A number of developing states — including Pacific Island countries with national experience of deep-sea mineral management — appear keen to play an increasingly influential role at ISA. There have also been greater numbers of non-governmental observers, and calls for greater access to ISA proceedings. ISA bodies have themselves acknowledged the importance of drawing on wider expertise in navigating difficult regulatory decisions ahead. ISA has recently run a number of stakeholder workshops and public surveys, seeking wider input. These consultative approaches are to be applauded.

Of particular note is this year's ISA Discussion Paper on the "Development of Environmental Regulations for Exploitation in the Area." The paper describes well, and dauntingly, the wide range of deep-sea mining environmental management issues yet to be agreed before coherent regulation can take place.

The number and scale of questions about how to control the impacts of this fledgling industry are considerable. How ISA will function in practice as a mining regulator is not articulated. Will ISA house an environmental authority, running a permitting process quite independently from the issue of mining rights or collection of mining revenue? The current composition of skeleton secretariat and annual decisionmaker meetings certainly does not appear fit-for-future-purpose.

But comfort can be taken from ISA's reiteration that "no single element or package of the regulatory code would be agreed upon until everything was agreed," indicating that no mining contract can be issued until an environmental management regime is fully in place.

A precautionary pace and participatory approach from ISA provides an unusual opportunity now to agree on boundaries for this new extractive industry before it's up and running. Balancing economic development against environmental protection is a familiar modern dilemma. But applying it to the deepest reaches of our oceans, on behalf of "humankind as a whole," requires a new, radical vision. Drafting legal regulations in such circumstances is tricky, but the real challenge will be for ISA in adjudicating where humankind's values lie.

Hannah Lily is a lawyer at the Commonwealth Secretariat, where she advises commonwealth governments on good governance of oceans and natural resources. She has drafted deep-sea laws for a number of countries, including Fiji, Tonga, Tuvalu, Nauru, and the Cook Islands.

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Phased Approach and Permanent Protections

By Kathryn Mengerink

With limited exceptions, the overwhelming truth of the deep sea is that we do not know what is there, we do not how it works, and we do not know how to fix things if we break them. These unknowns are both what makes the deep sea a fascinating place, and what may be its Achilles' heel — out of sight, out of mind.

Enter deep seabed mining, touted as an opportunity to move destructive terrestrial practices offshore where the impacts, especially to human communities, will be drastically reduced and where abundant materials in the ocean are ripe for the picking.

The International Seabed Authority is now tasked with both protecting the living resources of the deep sea and enabling the exploitation of seabed mineral resources. To do this, ISA is designing a system of environmental regulation for more than half of the world's seabed. While this vast area may seem to supply limitless resources, the human species has demonstrated repeatedly that it is well-equipped to deplete even renewable resources and cause irreversible damage to marine species and ecosystems.

Cumulative effects caused by seabed mining will vary given the type of mining proposed. For polymetallic nodules, millions of square kilometers of seafloor serve as potential mining sites and alternatively provide an ecosystem for deep sea organisms. It may be that thousands of square kilometers can be mined before cumulative effects create significant or serious harm.

In contrast, polymetallic sulfide mining of hydrothermal vent fields will occur over a smaller area with potential vent fields found on a scale of tens of kilometers in size with only a few hundred such sites known worldwide.

If all the world's seabed mining sites are fully exploited, certainly the impacts would be catastrophic. It is also true that a small amount of impacts to these vast resources may not have globally or even regionally significant impacts. The challenge is to determine whether there is a certain amount of mining that can occur, given the need for substantial precaution.

With these realities in mind, this article focuses on three ways ISA can design environmental management to address cumulative effects through a phased approach and permanent protections.

First, ISA should create a tiered system of phased assessment and decisionmaking similar to that created under the U.S. Outer Continental Shelf Lands Act in order to evaluate impacts and make go/no-go decisions at each point in the process. Such an approach would include a planning phase to evaluate what areas to offer for exploitation contracts.

The next phase would allow for the issuances of contracts based on a subset of possible areas. The third and fourth phase would allow for exploration and exploitation respectively.

Each phase in the process would include an environmental impact assessment. During the exploration phase, ISA should allow limited test mining to make initial observations to determine if actual impacts are within the bounds of predicted impacts. Only if impacts are within acceptable limits as predicted should ISA approve commercial exploitation.

Finally, ISA should determine a cut-off point beyond which no additional mining will be allowed by any company or country — in other words, once an area has been mined the remaining unmined resources should be permanently protected from additional disturbance.

Second, ISA should create a system of mitigation that includes avoidance and minimization of impacts, as well as restoration of areas where avoidance and minimization does not effectively address the harmful effects of mining. Such restoration should focus on protection as the key. When protection is used as restoration, compensation ratios should be high. As an example, 10 hectares of protection for every 1 hectare destroyed is common for wetland restoration.

In the case of the deep sea, where the knowledge and tools to restore damaged ecosystems are lacking, ISA should consider permanent preservation as core mechanism of restoration. To accomplish this, ISA should permanently protect areas based on the area mined using compensation ratios that are substantially higher than 10:1, perhaps 100:1 or more, given the unknowns and unknowable nature of the deep sea.

Third, ISA should develop predetermined end points beyond which no mining will occur for all seabed resources. To avoid cumulative impacts, it should decide now what the limits of mining will be, so that all countries and contractors have adequate notice regarding the ultimate extent of mining.

In summary, ISA should design a system that builds permanent protection as mining sites are released, create a tiered system of exploitation and decisionmaking to determine when and if to allow mining to occur in a given area, and a predetermined end point beyond which no mining will occur.

Kathryn Mengerink is executive director of Waitt Institute.

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All Stakeholders Contribute in ISA Oversight Role

By Sandor Mulsow

There are three major minerals that are considered as potential sources of metals coming from the seafloor beyond national jurisdiction, a territory known as the Area. The most known of these minerals and the first discovered is polymetallic manganese nodules. PMN is rich in manganese, iron, copper, nickel, cobalt, and rare earth elements.

In 1971, efforts by the U.S. National Oceanic and Atmospheric Administration located some new structures on the seafloor, now known as active hydrothermal vents. They provide polymetallic massive sulphides deposits rich in many of the same elements plus silver and gold. PMS deposits are found at the mid-ocean ridges where the seafloor is forming.

Three decades ago, Japanese scientists reported the third mineral ore from the ocean floor, cobalt crust, from their continental shores southwest of Hawaii. CC is as important as PMN and PMS for mining companies and contains many of the same elements.

The uniqueness of these resources poses not only technological and environmental challenges, but also — because they are significantly distributed throughout the Area — a governance challenge as well. The latter issue prompted the General Assembly to create the UN Convention of the Law of Sea, which entered into force in 1994.

With the implementation of UNCLOS, the International Seabed Authority was born, with the crucial mandate to regulate exploration and exploitation of seafloor resources and take measures to protect the marine environment from harmful impacts from such activities. ISA, as a regulator, sets the guidelines and rules and regulations for the application of contracts for exploration and exploitation of deep-sea metals from mineral resources in the Area.

To date, there are 17 contracts granted for PMN; 4 contracts approved for PMS; and 6 contracts for CC. The total area under contract is distributed in the Pacific Ocean, Indian Ocean, and North and South Atlantic Oceans. As regulator, ISA has to date issued or generated important documents during the last 20 years; developed rules and regulation for exploration for PMN, PMS, and CC; and adopted an environmental management plan for the Clarion-Clipperton Fracture Zone in the Pacific as an area of particular environmental interest. Currently ISA is developing the framework for a code for mining exploitation, including a financial regime, and regional-scale environmental management plans for the Indian, North Pacific, and Atlantic oceans.

Independent of the type of mineral deposit targeted, they all are found under water, which creates operational challenges. Only a few collecting devices have been designed to harvest nodules. Some tests have been carried out in shallow waters only. In addition, the scale of metallurgic tasks and separation methods has not yet been clearly defined. The transport of the mineral from the source to the metallurgic industrial complex, however, may not be a problem using large barges.

The Atlantis II Project is a joint venture between Saudi Arabia, Sudan, and Diamond Fields Inc. in the Red Sea. The resource is located below 1,000 meters and to date the development of this project is pending on the resolution of an internal contract dispute. At this particular site, the mineral resource targeted is PMS. Because contracts licenses for exploration for PMS and CC in the Area have been granted only recently (2011-14) by ISA, very little knowledge and technological developments have been disclosed to the regulator.

The environmental challenge of deep-sea mining is perhaps the most important issue that must be addressed, with strong responsibility by all stakeholders: private industry, member states, ISA, nongovernmental organizations, and the worldwide scientific community. The mining of PMN, PMS, and CC requires processes to collect, crush, grind, lift, raise, and dewater deep-sea interfaces.

The scale of collecting ores at any given time is not yet clearly established and will depend on which ores are sought, among other mining production criteria. Most of the information that ISA gathers for environmental baseline studies comes from the contractors under their approved plans of work. Currently, ISA is implementing its data management plan to provide useful information to stakeholders in the near future based on that information.

Contractors also provide the means for directly supporting the training program for ISA, which effectuates technology transfer. The program started in 2013 and a total of 45 candidates, from 30 different countries, have completed training at sea and in laboratories, provided by 9 contractors. In 2017, 5 more candidates have been awarded places for training. This task, narrowing the gap of knowledge and technology of undeveloped countries and coordinated by ISA, could not be sustained without the direct support of contractors.

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Mining the Sea Floor Is a Plunge Into the Unknown

By Verena Tunnicliffe

Mining will be the greatest assault on deep-sea ecosystems ever inflicted by humans. We understand the potential profits from mining, but the full extent of the overall costs remains elusive. A clear mandate for the International Seabed Authority is to manage the seabed for the benefit of humankind. It is time to consider the full range of benefits that the seabed currently provides and what may be lost.

Current interests focus on two resources. Polymetallic nodules extend over large areas of abyssal plain at depths of three to six kilometers, where they have taken millions of years to form. Sparse research studies describe an ecological community linked to the nodules, with mostly unknown species. Recovery of test-mined sites remained limited after 26 years of experimentation, with notable effects even in small trial mining plots.

The other resource is metal-rich sulphide ores that form at hydrothemal vents, where high densities of species, known nowhere else, cluster around oasis-like hot springs. The mining targets are large ore deposits that have accumulated species over long periods. We have no data on ecosystem recovery from disruption at such stable sites. While research (including my own) on erupting volcanic sites records rapid recovery of certain vent communities, here the small chimneys are of little mining interest.

Conservative estimates indicate that potential metal yields from nodules in the central Pacific will be large enough to affect global metal markets. In contrast, hot vent deposits worldwide are low in yield in small sites only hundreds of meters on a side. The low return from vent deposits is unlikely to impact metal markets. Nonetheless, technology and permits are ready to initiate mining of vents in national domestic waters.

What are the costs? This estimate is considerably more difficult, even in the relatively well-known hot vent system. Lost existence is a cost. Lost biodiversity is a foregone opportunity for future generations. In the forty years since their discovery, hydrothermal vents have opened deep new knowledge around the origin of life, fundamentally novel metabolic pathways, and astounding adaptations to extreme conditions. NASA's planned mission to Europa is founded on the proof of life in hot, anoxic water at vents. Key innovations of vent life continue to inspire — what cost the lost access to sources of inspiration for new ideas, new products, and even creative works?

The UN Convention on the Law of the Sea does stipulate requirements for protection from harmful effects. As mining will certainly induce harm, the Mining Code must reflect the international community's decisions on how much harm is allowable. These definitions must include lowest impact on the regional ecosystem with the assumption of permanent loss of habitat in the mined area. Consideration of cumulative impacts of climate change, fishing. and other stressors is necessary.

Other international instruments also inform development of the Mining Code in the context of conservation and sustainable use of biodiversity in the mining area; in particular, Convention on Biological Diversity and Food and Agriculture Organization precedents are available. For example, FAO guidelines identify active vents as Vulnerable Marine Ecosystems that are to be avoided by fishing gear. Further guidance from the 2030 Agenda for Sustainable Development is under formulation, especially with the SDG14 Conference on oceans this June.

As exploitation plans proceed, so must the conservation plans that have drastically lagged the release of exploration licenses. Consequently, current areas set aside as untouched habitat in the mid-Pacific nodule province do not include high-density nodules; there was no room for them. A major concern is the impact from suspended mining plumes and associated toxic compounds that can travel long distances. Thus, the Mining Code has to set requirements for baselines, plume modeling, monitoring, and databases; in addition, triggers for stop-orders must be defined. Such issues will require research to determine limits.

Regulations should ensure that genetic material can continue to exchange among populations at tiny islands of hot vents and among discrete patches of nodules. Is a mine target a major source for larvae in the region? Will removal have a broad regional effect? The International Seabed Authority needs an overview greater than each contract area to define and achieve regional (even global) environmental objectives. This requirement lies outside the contractor-specific Mining Code.

We are embarked on an unprecedented endeavour. Benefits to humankind of metal reserves at active vents are not worth the potential losses in fundamental knowledge and biotechnology products that continue to accrue. Active vents should be closed to mining; inactive deposits should attract the interest to test mining benefits. For nodules, research must accelerate to identify key locations to form true marine protected areas in perpetuity. This gold rush needs some strong traffic control in regulation.

Verena Tunnicliffe is Canada research chair in deep oceans and professor at University of Victoria, concentrating in exploration and research in hydrothermal vents.

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