Deep-Sea Mining Decoded:

What Experts Want Decision Makers to Know

Image courtesy of the Ocean Exploration Trust

Foreword

Palais de Monaco

Many of the environmental challenges our Planet faces are concentrated in the ocean, particularly in its deep regions. In these largely unexplored and insufficiently protected areas, we find a microcosm of the broader issues confronting us.

Firstly, there is a significant lack of knowledge, as these remote and obscure ecosystems have long been perceived as barren wastelands. Secondly, there is an absence of protective measures that are truly adapted to current challenges. Finally, technological advances are reshaping our outlook, making deep-sea resources that were once inaccessible, and, above all, turning these resources—central to certain industries in the energy and digital transitions—into critical stakes for our future.

This situation is not a foregone conclusion. Science is progressing rapidly. The ocean is increasingly central to the international agenda, and tools for its protection are proliferating.

However, this trajectory is not inevitable. Scientific progress is accelerating, the ocean is gaining prominence on the international agenda, and new tools for its protection are emerging. Moreover, viable alternatives to deep-sea resource exploitation are being developed.

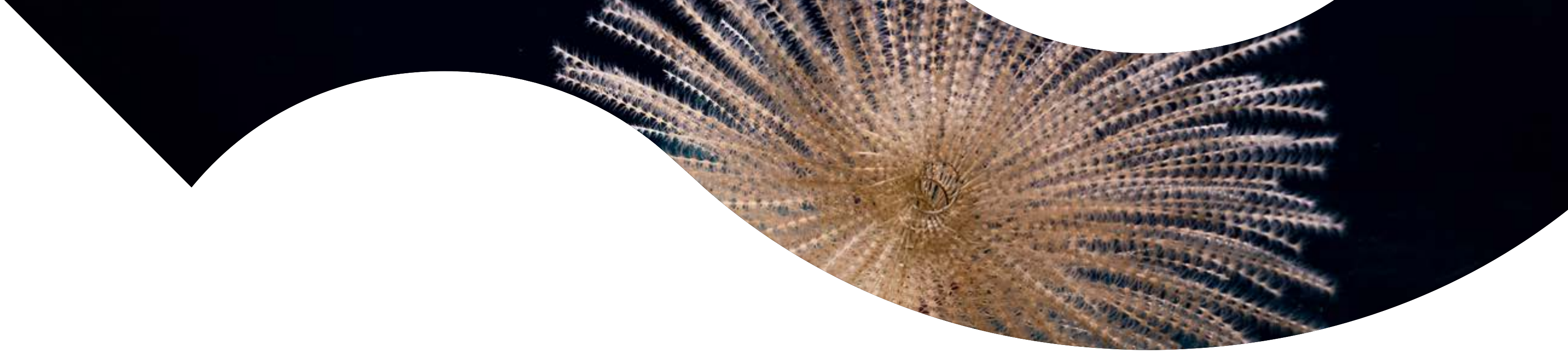
Until these solutions gain traction, the immediate priority must be to protect these fragile areas. We must allow science to advance and provide the evidence needed to shape coherent policies for the future.

The immediate need is to adopt a precautionary principle for deep-sea mining—this is the only viable way to ensure that scientists can conduct their work without hindered and that a sustainable approach governs these vital regions.

The methodology reflected in this work—embracing diverse expertise and a broad scope of inquiry—must also guide our approach in June 2025 at the United Nations Ocean Conference in Nice.

Monaco, which will host a Blue Economy and Finance Forum on the eve of UNOC, will do everything in its power to advance this agenda—the only path capable of safeguarding both the future of ocean ecosystems and that of generations to come.

His Serene Highness Prince Albert Alexandre Louis Pierre Grimaldi, Prince of Monaco



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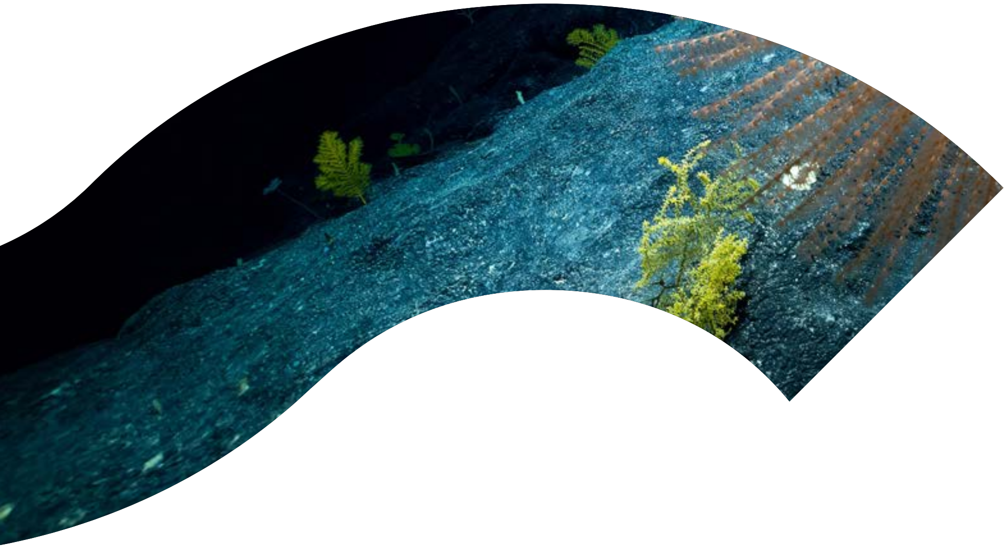


Deep-Sea Mining Decoded: What Experts Want Decision Makers to Know

This document presents a collection of the most pressing and relevant questions about deep-sea mining, carefully crafted by scientific members of the Global Deep-Sea Consultation. These questions address key concerns and knowledge gaps that decision-makers should consider. To provide comprehensive and insightful answers, these questions were directed to diverse voices, including natural scientists, economists, lawyers, industrials, representatives of indigenous communities, and early career ocean professionals, reflecting perspectives from many countries across the globe. Their insightful responses reflect a wide range of perspectives and aim to support informed decision-making and a deeper understanding of the complexities surrounding deep-sea mining.

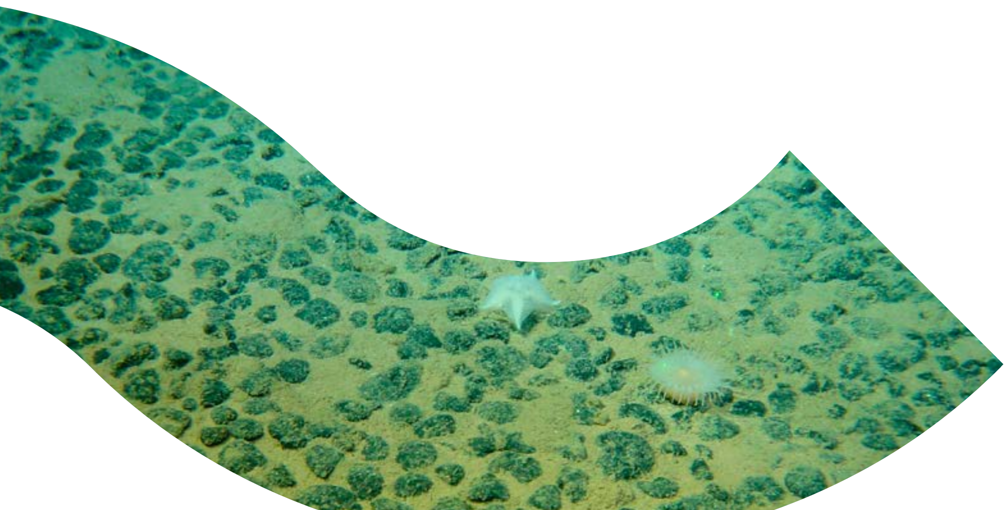
Image courtesy of Ifremer

The deep sea is the single largest ecosystem on our planet. It is also the ecosystem we know the least about. We asked experts to explain why the deep sea is important, not just as an ecosystem, but as a key global player in our climate, economy, and culture.

Why is the deep sea important?

Elisa Morgera, UN Special Rapporteur on Climate Change and Human Rights and Distinguished Professor of Global Environmental Law, Strathclyde University, UK

> "
> The deep sea is an essential contribution to everyone's human right to a healthy environment: it is important for its contributions to the production of the oxygen we breathe, as well as to climate regulation and the global water cycle. In addition, the deep sea is a unique space to learn about what makes life on this planet possible and make discoveries that can help advance medicine or food security – this is essential to everyone's human right to health, food and to science.
>
> And we are still in a process of understanding how diverse cultures and dimensions of human well-being are intimately connected with the deep sea in ways that reflect broader inter-connections across space and time. Advancing this knowledge, and sharing equitably the opportunities to participate in this area of knowledge production and in the benefits arising from these scientific outcomes, is of paramount importance for humankind, including past, present and future generations.



Vanessa Lopes, Nippon Foundation - University of Edinburgh Ocean Voices Programme Fellow, Cabo Verde

> "
> The deep sea is of great importance to the community in Cabo Verde. Cabo Verde is considered a large ocean state, with most of its territory covered by the ocean. Due to its archipelagic nature and volcanic islands, a large part of the ocean is considered deep sea. The deep sea in our community is fundamental for the livelihoods of coastal and fishing communities across all inhabited islands serving as their primary source of income. In addition, it is an area of high importance to our ecosystem, serving as an ecological corridor and breeding zone to different species and it is home to various seamounts. It serves as a feeding ground for migratory megafauna including, cetaceans, elasmobranchs, large pelagic fishes, and as a feeding zone to seabirds. While the deep sea in Cabo Verde remains vastly unexplored, due to capacity limitations, further research and exploration are essential to understand possible threats and additional conservation measures to be taken.

Kerry Sink, South African National Biodiversity Institute Principal Scientist and Nelson Mandela University Associate Professor, South Africa

> "
> The deep sea is important because of the life it hosts, the climate and nutrient cycles it sustains, the awe it inspires and the opportunities it provides. The deep ocean has profound scientific, environmental, economic and cultural value. Although scientists have made progress in exploring and surveying the vast deep, they are still making important discoveries. The deep sea has often surprised us and continues to hold many secrets. Unique deep-sea ecosystems like seamounts, chemosynthetic seeps and vents and abyssal plains are home to animals adapted to these extreme environments in amazing and useful ways. As new technology and generations uncover novel insights, an increasing diversity of benefits are revealed. The deep sea holds clues to the origin of life on earth and our climate history, and the deep decisions we make now, will influence our future.
>
> In Africa, the deep sea is reflected in cosmologies, oral tradition, rituals and beliefs and holds significant spiritual value. Much of the deep sea is the common heritage of mankind, presenting unique opportunities for global collaboration and co-operation for inspirational discoveries and actions that sustain life on earth and contribute to the achievement of global goals for climate, biodiversity and equality.

We know the deep sea performs critical ecosystem functions which regulate our climate and hold economic value. It also holds societal and cultural importance with Indigenous peoples being intrinsically connected to the deep sea. However, our understanding of the deep sea is incomplete, especially when compared to the knowledge we have of other ecosystems. We have visually studied and researched less than 1% of the deep sea, and only have high-resolution maps of ~25% of our global seafloor. This means scientists frequently make exciting discoveries in the deep sea, such as the ground-breaking 2024 discovery of dark oxygen being produced in the deep sea.

As a researcher who contributed to the discovery of dark oxygen research, could you please describe what this finding means for deep-sea science and ocean exploration?

Alycia Smith, National Oceanography Centre Science Coordinator, UK

> “
> There is a consensus among scientists that knowledge of the deep sea is scarce; the recent discovery of dark oxygen production in a polymetallic nodule field reinforces this concern. We believe this process to be directly related to the presence of nodules, hypothesising production through seawater electrolysis. Oxygen is important for all aerobic life, and on the global scale that polymetallic nodules cover the abyssal seafloor, dark oxygen production may act as a significant source in the global oxygen cycle. As nodules may soon be targeted as a resource for valuable minerals, without further investigation, we remain unaware of the potential impact of mining activities on this vital ecosystem service. This finding challenges the traditional belief that naturally produced oxygen comes only from photosynthesis in the presence of sunlight and highlights the importance of further exploring the deep sea, to characterise and preserve its function in future.

The discovery of dark oxygen occurred in the Clarion-Clipperton Zone, an area of the deep sea which contains polymetallic nodules. These nodules, along with the other two main types of mineral resources - hydrothermal vents & massive sulfides – contain minerals such as cobalt, copper, manganese, nickel, and rare earth elements. All three are being considered for mining.

Why are certain countries and companies interested in mining the deep sea?

Gideon Sarpong, iWatch Africa Co-Founder, Ghana

> “
> Countries and companies are increasingly interested in deep-sea mining due to the vast reserves of critical minerals such as cobalt, nickel, manganese, and rare earth elements found on the ocean floor. These materials are vital for renewable energy technologies, electric vehicle batteries, and other innovations driving the green energy transition. With terrestrial mineral supplies dwindling and subject to geopolitical tensions, the deep sea represents an attractive but controversial frontier.
>
> However, as the founder of the Sustainable Ocean Alliance Ghana Hub, I advocate for a complete ban on deep-sea mining. The risks are profound: inevitable and irreversible biodiversity loss, disruption of marine ecosystems, and further inequities in resource exploitation. Moreover, the ocean plays an essential role in regulating the climate, and its health is already compromised by issues such as plastic pollution and illegal fishing. Opening the deep sea for commercial mining could trigger catastrophic repercussions, undermining its critical functions and threatening global sustainability.

Image courtesy of Ifremer

How has the narrative supporting deep-sea mining motivations shifted over time?

Peter M. Haugan, Institute of Marine Research Policy Director and University of Bergen Professor, Norway

> "
> Deep-sea mining emerged as an idea in the 1960s as part of a techno-optimistic vision that also included the establishment of underwater cities. Nodules appeared easy to collect, and the Law of the Sea was developed with provisions to ensure equitable sharing of prosperity arising from deep-sea minerals. The potential role of deep-sea minerals for a green shift only entered the discussion after 2010 and now appears to take centre stage in the debate globally. However, in Norway which has opened its shelf for commercial deep-sea mining, the discussion as late as 2020 still centered on the prospects of prosperity as the key motivation. When concerns were raised about technological challenges, building upon the world leading offshore oil and gas technology from the North Sea was cited as a quick fix. Responsibility to contribute to the green shift only became key in the national debate when concerns were raised about the cost of developing and scaling up technology for production of the sulfide and manganese crust resources. During the last two years geopolitical issues around competition with China and military mineral needs have become dominant. What is the real motivation?

If a company or country is interested in mining the deep sea, who gets to decide if mining will progress or not?

Pradeep Singh, Research Institute for Sustainability (RIFS) Fellow, Malaysia

> "
> In areas within national jurisdiction (i.e. on the continental or extended continental shelf of a coastal state), states have sovereign rights over the seabed mineral resources. That however does not mean that they can explore or exploit these resources with impunity. The UN Convention on the Law of the Sea (UNCLOS) requires coastal states to develop environmental frameworks and policies, and subjects the sovereign rights of states over ocean resources to their obligation to protect and preserve the marine environment. Thus, while governments can take decisions relating to mineral resources within national waters, they are required to establish adequate procedures, conduct national consultations, ensure appropriate scientific criteria are in place and environmental impact assessments are carried out, provide sufficient notifications to other states, and so on. Decisions by governments that are alleged to be inappropriate or in excess of powers can be challenged in national courts, in accordance with the domestic legal systems, as well as in international courts.
>
> In seabed areas beyond the limits of national jurisdiction, i.e. the Area, these minerals are the common heritage of humankind and fall within the remit of the International Seabed Authority (ISA), a multilateral international body. All member states to UNCLOS, now at 169 states, are parties to the ISA. While all states can participate in the development of regulations relating to the exploration and exploitation of the mineral resources of the Area, executive decisions such as whether or not to approve a mining application is made by the Council, an organ represented by 36 states. The decisions of the Council relating to mining applications are highly dependent on the nature of the work carried out by its subsidiary body, the Legal and Technical Commission, who evaluates the technical aspects of the application and makes recommendations to the Council on whether to approve or reject it.

The deep sea is an understudied, and often undervalued part of our planet. Let's understand what deep-sea mining would mean for this fragile marine ecosystem. Marine scientists have carried out studies to understand and predict how potential deep-sea mining would impact deep-sea environments, animals, and ecosystem functions.

Are deep-sea mineral resources themselves important for sustaining marine biodiversity?

Anna Metaxas, Dalhousie University Killam Professor, Canada

> "
> Deep-sea mineral resources are embedded within the habitats of ecological communities, making up the substrate used by species to anchor themselves. Many species (most unknown to science) anchor onto the hard structure of manganese nodules. The nodules also add three-dimensional structure in the relatively flat sediments of the abyssal plains, forming microhabitats underneath and between them which are occupied by species that live on the sediment surface. The sulphide deposits at hydrothermal vents provide substratum for anchoring lush, endemic communities at active deposits and indicator species of vulnerable marine ecosystems, such as deep-water coral or sponge gardens, at inactive deposits. Cobalt crusts form part of the seabed matrix on the flanks of seamounts where deep-water corals and sponges attach. Many of the larger species are ecosystem engineers, creating three-dimensional thickets or forests that provide nurseries, access to food and protection for many other organisms. Extracting the mineral resources will completely remove the substratum and all the fauna associated with it. Given the life-history strategies of many of these ecosystem engineers, extraction will hamper the potential for recovery of the ecosystems they support and will result in a net loss of biodiversity locally and possibly regionally, depending on the scope of mining operations.

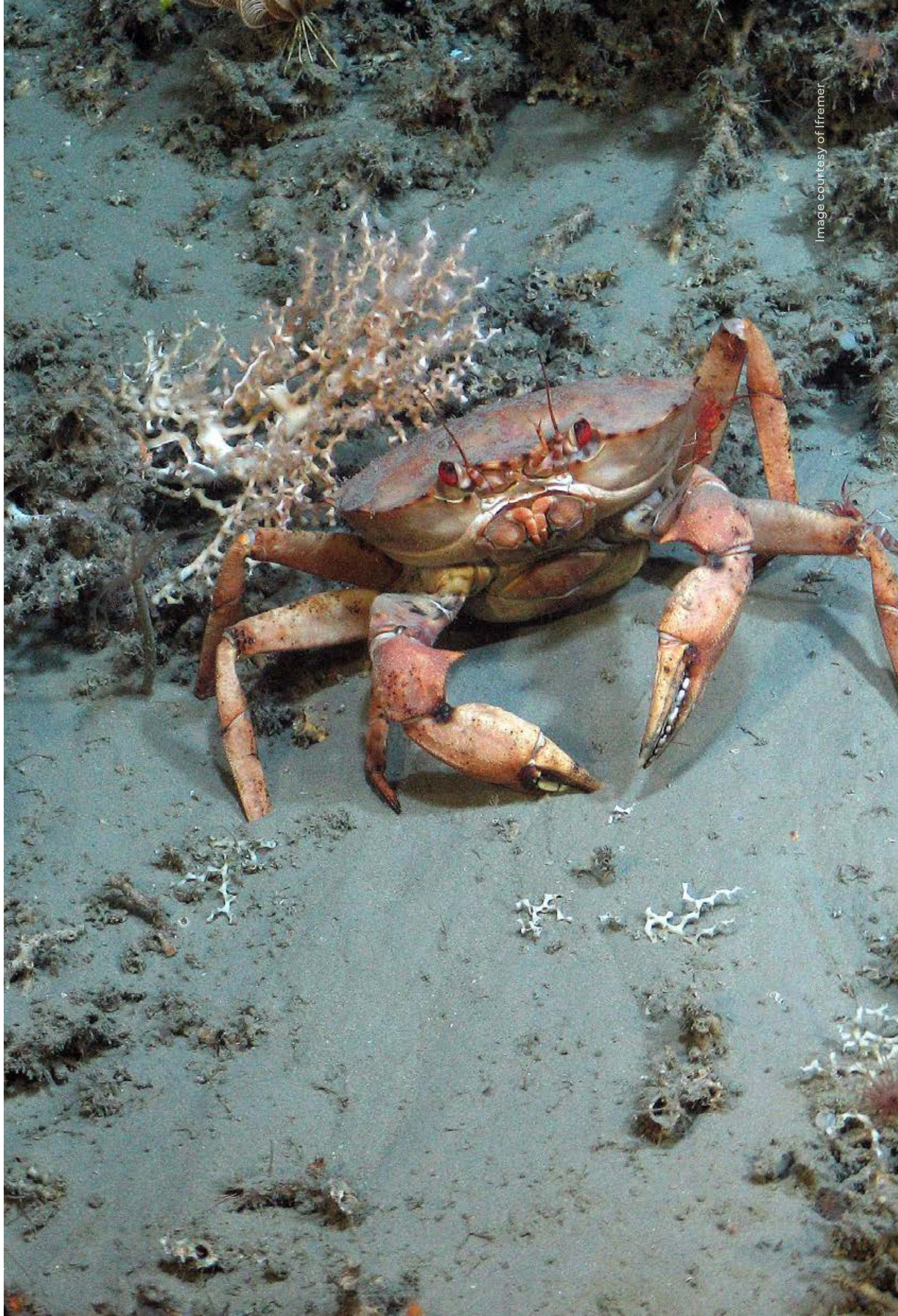


Image courtesy of Ifremer

The removal of deep-sea mineral resources would impact seafloor biodiversity. Would deep-sea mining impact animals beyond the seafloor?

Ricardo Serrão Santos, University of the Azores Honorary Researcher, Portugal

> "
> Deep-sea mining activities carry risks that go beyond just the seabed and call for thorough assessment and control measures. Deep-sea mining could have reaching effects on life beyond just the seafloor itself. While a lot of research has concentrated on the impacts on bottom-dwelling ecosystems, recent studies have uncovered substantial risks to creatures living in the midwater regions as well. The operations involved in mining produce sediment plumes that can spread across expanses of water bodies while carrying particles and dissolved metallic substances along with them. These plumes hold the potential to block feeding mechanisms of filter feeders such as jellyfish and certain crustaceans and also dilute food sources that are crucial for sustaining life in the midwater layers while significantly disrupting the delicate balance of the midwater food chain as a consequence.
>
> Moreover the release of mining waste into the water can last for a long time and spread across vast distances through ocean currents. The discharge of mining tailings into the water column can persist for years. This dispersal endangers a range of midwater creatures including squid and fish well as zooplankton that are essential for nutrient recycling and carbon sequestration. Noise pollution and vibrations produced by mining machinery also raise concerns as they might disrupt the activities of animals, like whales that heavily depend on cues.
>
> The consequences of these changes could potentially disrupt functions that link the depths of the ocean throughout the entire water column to the epipelagic regions.

Sheena Talma, Oxford University DPhil Fellow and Talma Consultancy Director, Seychelles

> "
> Perhaps our greatest failure as a society is viewing systems in isolation, as though one part functions independently of the others. For example, we treat the seafloor and water column as separate entities, ignoring their profound connection. The truth is that everything in the ocean is interlinked. Currents carrying cold water from the poles and warm water from the equator sustain life on Earth. However, this connectivity could become a vulnerability in deep-sea mining.
>
> Mining polymetallic nodules occur at depths over 4,000 meters, like stacking four Burj Khalifas. These mineral-rich "potatoes" are marketed as essential for renewable energy. On the surface, it seems straightforward: collect rocks and leave. But it's far messier. Beyond seafloor damage, mining triggers cascading effects through the ocean system, from benthic ecosystems to midwater and surface life.
>
> Sediment plumes, created by mining equipment and waste discharge, spread particles, disrupting filter feeders and altering ecosystems. Noise pollution affects species relying on sound, while chemical pollution alters water chemistry. Disrupted migrations, ship strikes, and carbon cycle interference risk biodiversity and climate regulation.
>
> The deep sea's connectivity reveals that localised mining can ripple across ecosystems, affecting life far from its origin. If we exploit this habitat, we must proceed cautiously, fully considering long-term consequences. The ocean thrives through connection, sustaining life across scales—a balance we cannot afford to disrupt.

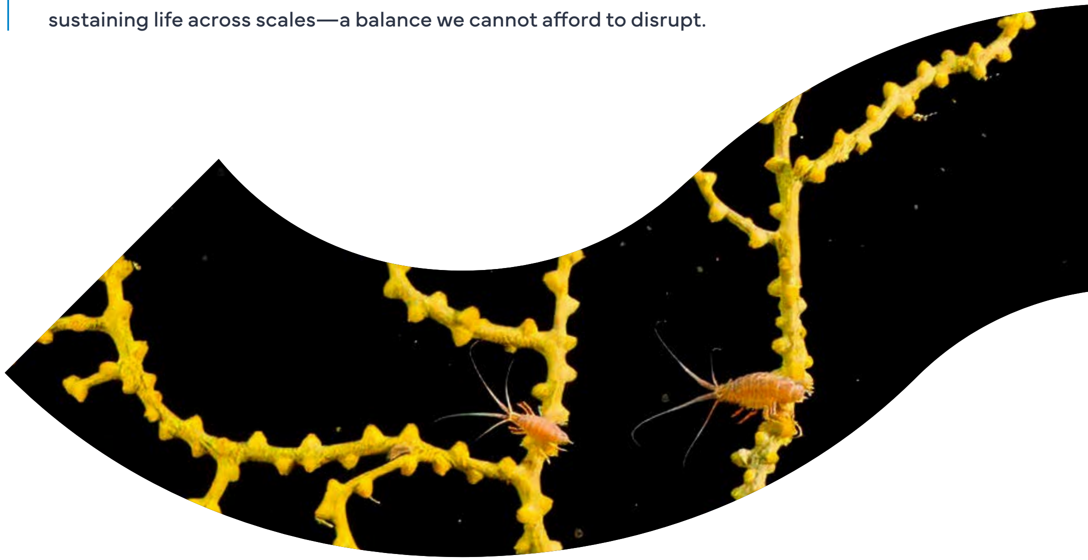


Image courtesy of the Ocean Exploration Trust

The majority of research to understand environmental impacts has focused on the seabed itself. What are the environmental concerns surrounding a mining vessel's discharge plume into the water column?

Sergio Cambronero Solano, National University of Costa Rica Research Associate, Costa Rica

> "
> The primary concern with mid-water discharge plumes is the technological adaptability of vessels to control discharge depths effectively and the capability to modify if necessary to comply with thresholds. The marine water column, representing 96% of Earth's water volume, is a vast biome where complex biogeochemical and oceanographic processes occur, including the largest Oxygen Minimum Zone (OMZ), right next to the CCZ in the western flank of Central and North America. Recent advances show how OMZ thickness can change over time and space, prompting further research into climate impacts and essential ecosystem functions like carbon and nitrogen cycling. The addition of materials containing metals and organic matter into this environment could alter and disrupt these processes. Another concern is the cumulative and transboundary impact of midwater plumes, which, unlike benthic plumes, interact with more frequent and higher magnitude mesoscale processes that transport water across long distances both vertically and horizontally, also interacting with geostrophic currents, upwelling and downwelling patterns. To understand these interactions before any commercial activity, predictions must be refined to account for plume spread, depth, and accumulation, particularly in the Pacific. Without careful assessment, these processes may affect the OMZ's role in carbon sequestration and influence nearby Exclusive Economic Zones. In this regard, biodiversity is sensitive to changes, with biological communities like gelatinous plankton and microbial life in the water column potentially affected by discharge plumes containing higher concentrations of salts, metals, ions, and particles. These plumes could disrupt local to regional ecosystems, posing risks to biodiversity, midwater ecosystem balance, and fisheries that many regions rely on.

Do we have any idea of the time and geographic scales environmental impacts from deep-sea mining would occur on?

Judith Gobin, University of the West Indies Professor (Retired), Trinidad & Tobago

> "
> As marine scientists, we cannot definitively project a timeline or geographical scale for the negative impacts of deep-sea mining. We can however say with absolute confidence and data that deep-water mining will alter the biological, biochemical and geochemical underpinnings of ocean life. Such alterations will result in the loss of marine biodiversity and genetic resources and will most certainly disrupt the connectivity between deep oceans and surrounding oceans, potentially hindering the flow of vital nutrients. These risks are inevitable and most likely irreversible. In effect, healthy oceans, which are vital for human beings as we know, will be destroyed.

Sabine Gollner, Royal Netherlands Institute for Sea Research (NIOZ), Senior Scientist, The Netherlands

> "
> Currently, ~2.7 million km2 of seafloor are being explored for metal ores, with expectations that a few hundred thousand km2 could be mined within the next 20-30 years. The ores, however, provide habitat. The biodiversity and ecosystem functions dependent on the ores are lost at the mined location for up to millions of years, the length of time it takes for the ores to form. This includes, for example, loss of biomass production by microbes and loss of fauna, such as sponges and corals, and the associated ecosystem services. Species extinction is likely and will be permanent.
>
> The geographic scale of mining plumes depends on the technology used and the location, but always extends beyond the mined seafloor area and reaches into the water column. Noise spreads over hundreds of kilometers in the water, and stops when mining operations stop, noting that these operations may last continuously for decades. Little is known on the impact of mining plumes or noise on deep-sea life, such as mortality, chronic toxic effects, change in behavior or reproduction that may impact subsequent generations.

Could deep-sea environments and species recover from the environmental impacts of deep-sea mining?

Baban Ingole, National Institute of Oceanography Former Chief Scientist, India

> "
> The deep-sea benthic environment is typically limited in food resources, with the exception of active hydrothermal areas. As a result, disturbances in these habitats can have prolonged impacts on ecosystem functions. Although natural ecological systems often react swiftly to disturbances, the restoration of lost species/populations depends on the extent of the disturbance. Generally, recovery is possible but occurs slowly. Additionally, the return of infrequent, low-density species may be hindered by challenges in finding mates, leading to potentially irreversible declines due to low reproduction rates. Conversely, species with large populations in the deep sea might withstand physical disturbances, yet their recovery pace is slower compared to species in shallower waters.
>
> Beyond environmental concerns, there are also socio-economic aspects of deep-sea mining which must be considered.

What ethical concerns exist surrounding deep-sea mining?

Endalew Lijalem Enyew, Norwegian Centre for the Law of the Sea Researcher, Norway

> "
> Deep-sea mining, be it within the extended continental shelf under the national jurisdiction of States or within the Area, raises several ethical concerns. I would like to highlight only one concern here. Scientists have been speaking out loud that there is currently insufficient scientific knowledge on the environmental effects of deep-sea mining. In addition to the potential serious risks to the marine environment, deep-sea mining may have significant impacts on the rights of indigenous peoples and local communities. This is mainly because many Indigenous peoples and local communities, particularly in the Pacific Island States and in Africa, have cultural heritage and sacred sites in deep-sea waters, or that the mining activities that take place in the deep-sea waters may impact the rights of Indigenous peoples in coastal areas due to the ecological connectivity of the oceans. Despite these potential impacts, the reluctance of States and the ISA to explicitly incorporate the implementation of human rights due diligence and meaningful consultation with Indigenous peoples regarding deep-sea mining activities is deeply concerning.
>
> Thus, in the face of scientific uncertainties, ethical concerns require considering Indigenous peoples' traditional knowledge seriously in decision-making processes and taking appropriate precautionary measures to protect what we do not yet fully understand. In this case, a precautionary pause, if not a permanent moratorium, on deep-sea mining may be a necessity. If deep-sea mining is to be allowed, it is essential that the environmental impact assessments (EIAs) be conducted with meaningful participation of indigenous peoples taking into due consideration of their traditional knowledge systems and that such assessment should include the socioeconomic and cultural impacts. Therefore, the ISA, governmental institutions, as well as concerned mining industries, have a legal and ethical responsibility to evaluate and adequately address the environmental and human rights impacts of deep-sea mining.

Image courtesy of Ifremer

What are the concerns among fishers and the seafood industry surrounding deep-sea mining?

Transform Aqorau, Solomon Islands National University Vice Chancellor, Solomon Islands

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The Pacific Islands' seafood industry faces significant concerns regarding deep-sea mining. Key issues include **environmental risks**, such as habitat destruction, sediment plumes impacting fish stocks, and disruptions to ecosystem connectivity. These could lead to reduced catches and biodiversity loss, threatening fisheries' sustainability. Economically, deep-sea mining may lower fish yields, damage the Pacific's sustainable seafood reputation, and restrict access to fishing grounds. Socially, it endangers traditional fishing practices and food security, eroding cultural ties to the ocean.

Regulatory gaps exacerbate fears, as many nations lack robust frameworks to mitigate deep-sea mining's impact on fisheries. The cumulative effects of deep-sea mining and climate change, such as sediment carbon release and stress on ecosystems, intensify these concerns. Addressing them requires rigorous environmental assessments, stakeholder engagement, and strengthened governance. Collaborative regional action and marine spatial planning are essential to balance deep-sea mining's economic potential with the seafood industry's critical role in Pacific livelihoods and identity.

As a member of the Ngati Raina tribe, what does your community think about the prospect of deep-sea mining?

Alanna Matamaru Smith, Te Ipukarea Society Director, Cook Islands

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Deep-sea mining is a complex issue here in the Cook Islands, particularly with our state not only having international interests with a joint venture partnership, but also national interests in deep-sea mining for Polymetallic Nodules. At a national level this interest has resulted in government-led community consultations being one sided, with presentations having an emphasis on the potential financial gains this industry could bring to our economy. These unbalanced consultations have resulted in our people being misinformed on the matter by not being made fully aware of the potential environmental risks this industry could have on our ocean, our food basket. Based on government consultations and what information NGOs have been able to share with limited resources, there has been a 50/50 split thinking on the issue. But with more information being shared regarding the many unknowns in the area of environmental risks and unknowns in the financial space, we are slowly seeing more community members become more cautious on the matter.

Under UNCLOS, states must preserve deep-sea ecosystems for future generations. As an ocean youth representative, what are your thoughts on deep-sea mining?

Sophia Laarissa, Early Career Ocean Professionals Africa Ocean Literacy Co-coordinator and Cadi Ayyad University PhD Student, Morocco

> "
> As a Moroccan woman and the Ocean Literacy Co-coordinator for ECOP Africa, I approach deep-sea mining with concern. My work with ECOP Africa has shown me how deeply African coastal communities depend on a healthy ocean for livelihoods, cultural heritage, and food security. The deep sea, though remote, plays a vital role in regulating the global climate and supporting biodiversity.
>
> Under UNCLOS, states have a responsibility to preserve these ecosystems for future generations. While I understand the economic motivations behind deep-sea mining, the risks to fragile marine ecosystems are immense and could have far-reaching consequences for biodiversity and communities that depend on the ocean.
>
> At ECOP Africa, we are committed to raising awareness and advocating for a moratorium on deep-sea mining until independent research ensures it can be done sustainably. Through initiatives like the Africa Ocean Literacy Hub, Blue Citizen project (in cooperation with ECOP Global Ocean Literacy Task Team) and our Blue Ocean Curricula for Africa (in cooperation with my Zalu), we strive to educate African youth and empower them to safeguard our ocean heritage.

Houangninan Midinoudewa, Benin Marine Conservation Club (BMCC) founder and ECOP Benin Node Coordinator, Benin

> "
> Deep-sea mining involves two antagonist faces. One related to the protection of the environment and the second related to the economic benefits that this activity can yield. As an Ocean youth representative from a developing country, which seeks to foster its economy by exploiting its offshore and deep resources, it is complex to stand against or for a position, as each position goes with its pros and cons. However, wearing my cap of scientist, a biological oceanographer having studied the current level of the pollution in my region using the marine organisms as proxies, deep-sea mining will generate more complex ecological consequences that the unknown and yet to study deep-sea ecosystems of the Gulf of Guinea could not withstand.

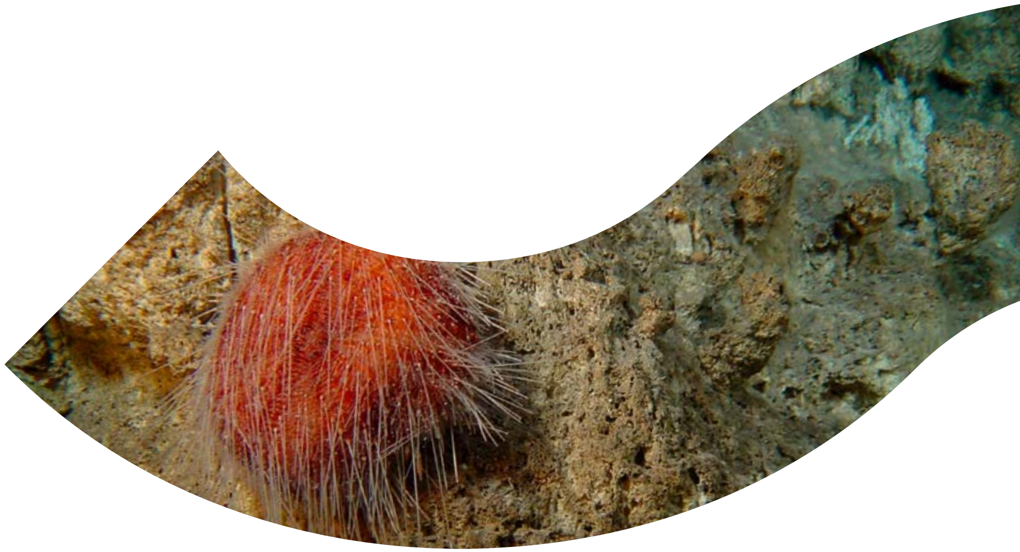
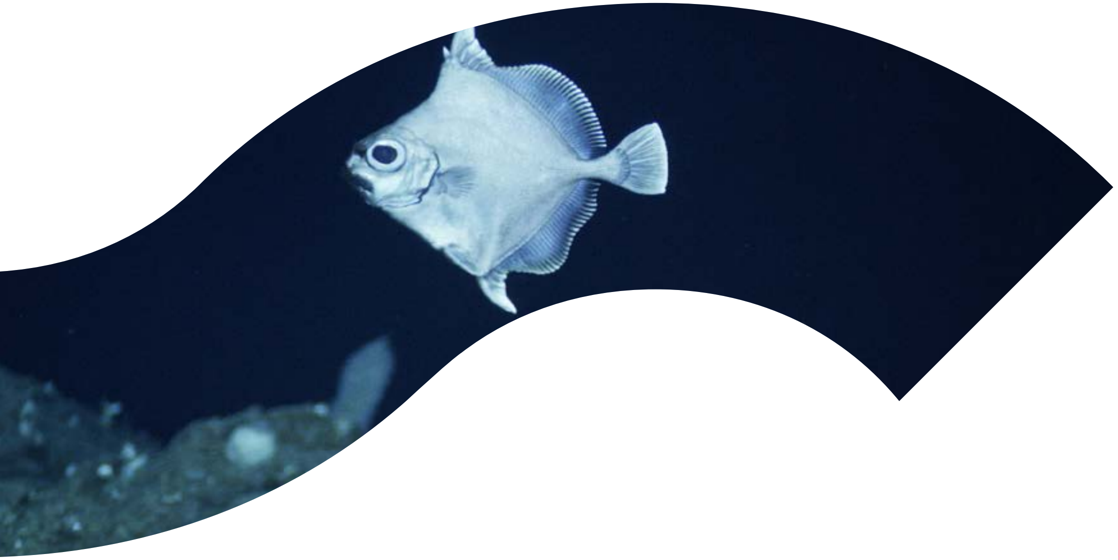


Image courtesy of Ifremer

Image courtesy of OceanX

How can we progress deep-sea ecosystem assessments to help put a monetary figure on the natural capital (economic value provided by natural resources) of the deep sea?



Torsten Thiele, Global Ocean Trust Founder, Germany

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The deep ocean provides important ecosystem services that are vital to life on Earth, from key regulating and supporting services to providing us with seafood and other resources. Human activities can cause ecosystem disservices, including biodiversity loss, chemical contamination and sedimentation, poisoning of non-target organisms, and emissions of greenhouse gases and pollutants, which need to be quantified in order to prioritise management approaches. The deep ocean still needs significantly more research to offer robust assessments, so rather than undertaking harmful activities without the ability to undertake such calculations the precautionary principle suggests focusing on assembling relevant environmental information first to describe appropriately the broad range of ecosystem services of the deep.

The study prepared by Dr. Luke Brander for the ISA in 2023 notes that deep-sea ecosystems provide essential services, including some of potentially high economic value which face high impacts from deep-sea mining. These include:

- Future value of genetic material for use in pharmaceutical and biotechnological applications;
- Existence and bequest values for preservation of remote and largely unknown biodiversity in the Area, and potential monetary values globally;
- The impact of mining activities on carbon sequestration by phytoplankton and other processes in the water column.

The study finds that research in EEZs provides estimates for four ecosystem services: food provisioning, genetic resources, carbon sequestration, and existence and bequest values. It suggests the development of a common reporting framework for further research into the economic value of ecosystem services in the Area, extending beyond the seabed to the water-column. Dr. Luke Brander suggests the following steps to value the impacts of resource exploitation on ecosystem services: description of investment activity, identification of impacts (e.g. through an Environmental Impact Assessment), biophysical assessment, economic valuation, investment evaluation, mitigation and/or compensation.

By undertaking the needed research in the coming decades and applying these established valuation approaches to the results we will over time be able put a monetary figure on the impacts of human activities on the natural capital of the deep sea.

Who stands to benefit from deep-sea mining, and what would those benefits be?

Jonathon Moses, Norwegian University of Science and Technology Professor, Norway

> “
> Given the ISA’s current regulatory framework, the greatest benefits from deep-sea mining will go to shareholders of those companies that secure exploitation licenses.
>
> The preamble to UNCLOS clearly states that these resources are the common heritage of mankind and their exploitation “shall be carried out for the benefit of mankind as a whole”. The challenge is in defining that benefit. For producers the benefit lies in bringing scarce minerals to market; poorer countries find it an opportunity to develop their own operational competencies; others find benefit in protecting these resources for future generations. If our focus is economic, the greatest benefits are found in what A.M. Brigham and I have called the Natural Dividend—the resource rents generated by the resource itself and the way it is managed on our behalf. This dividend can be substantial and belongs to all of us—it can be distributed or re-invested to ensure that future generations also benefit. Because the current regulatory framework does not recognize these rents, they are pocketed as profit. This needn’t be and shouldn’t be the case.


Image courtesy of OceanX

Image courtesy of NOAA Ocean Exploration

The ISA is mandated to facilitate benefit sharing of profits gained from deep-sea mining, but the costs (including to the marine environment) are likely to significantly exceed any financial benefits. How can an agreed-upon payment mechanism or benefit--sharing mechanism reflect this reality appropriately?

Nathalie Hilmi, Scientific Centre of Monaco Senior Researcher and Head of the Environmental Economics Section, Monaco

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The mechanism must take into account both the financial gains from resource extraction (short term) and the significant environmental and societal costs involved (longer run). The mechanism should incorporate True Cost Accounting (Environmental Costs) meaning not just financial costs but also the costs of environmental degradation. This means adopting a "polluter pays" principle where companies are responsible for the damage caused to ecosystems. To take into account the real value of the natural capital of the ocean, valuing ecosystem services provided by deep-sea environments can help in monetizing what is being lost. Such valuations could be used to calculate the financial compensation or fees deep-sea mining operators should pay. Instead of fixed royalties or fees, create a sliding scale where higher environmental damage or risk triggers higher financial contributions. This could incentivize more sustainable mining practices, as operators would be financially penalized for causing greater ecological harm.

Given the uncertainty and potential long-term impacts on marine biodiversity, establishing an Environmental Risk Insurance Fund that deep-sea miners contribute to would be crucial. This fund could serve to cover future remediation or recovery efforts in case of environmental damage that manifests years after mining operations. Moreover, since the environmental impacts of deep-sea mining are still uncertain, the mechanism should be designed with a precautionary approach. Financial penalties or increased payments could be triggered if certain thresholds of environmental degradation are crossed, effectively acting as a safeguard.
Finally, the payment mechanism must be multidimensional and equitable, addressing long-term sustainability and environmental stewardship. It would ensure that both present and future generations benefit from the responsible and sustainable use of the deep-sea resources.

There are potential legal issues surrounding deep-sea mining which stem from both environmental impacts and socio-economic aspects.

There are pre-existing international agreements such as The United Nations Agreement on Biodiversity Beyond National Jurisdiction (BBNJ) and the Convention on Biological Diversity (CBD). How would deep-sea mining in international waters interact with these agreements?

Bobbi-Jo Dobush, Salt Horizon Independent Ocean Conservation Policy Consultant, USA

> “
> Deep-sea mining would undermine global environmental commitments and obligations, such as BBNJ and the CBD (which creates the potential for liability) as well as regional commitments, such as for fisheries. Deep-sea mining operations would discharge metals-laden sediment into the water column, with potentially dramatic effect on the food chain all the way to commercially important fish. Noise pollution from deep-sea mining could interfere with marine animals, including whales. Deep-sea corals and marine genetic resources have also been found at risk, and the mineral substrates targeted by deep-sea mining are critical habitat for unique deep-ocean species. Deep-sea mining could also affect climate commitments by either disturbing stored sediment or altering the biological pump, which moves carbon from the shallows to the deep ocean. Importantly, deep-sea mining would undermine commitments regarding both cultural heritage and human rights, as evidenced by the increasing concern expressed by Indigenous groups from around the globe as well as Special Rapporteurs for human rights.

If deep-sea mining were to progress, who would pay for and carry-out the long-term environmental assessments outside the contractor areas according to standards, and what metrics would be used to track impacts and harm?

Aline Jaeckel, ANCORS University of Wollongong Associate Professor, Australia

> “
> There is no clear answer to this question yet. Even though Article 165(2)(d) of UNCLOS requires the ISA's Legal and Technical Commission to 'prepare assessments of the environmental implications of activities in the Area', no such assessment has been carried out yet, to the best of my knowledge. The provision implies that the ISA might carry the costs of such an assessment.
>
> The environmental impact assessments (EIAs) that have been conducted for mineral activities in the Area to date were carried out by ISA contractors, who are the operators of current mineral exploration work. In order to obtain an exploitation contract in the future, a contractor will need to conduct an EIA for its proposed activities that should consider the entire "Impact Area", which may include areas outside the contract area, though that remains unclear. Some states are arguing that the impacts of a mine site should be limited to the contract area and water column above, so as to protect adjacent areas and also to protect other contract areas from cross-pollution etc, which could make environmental monitoring rather difficult.
>
> There currently are no agreed binding Standards for assessing the environmental impacts of seabed mining activities in the Area. This is a topic of ongoing discussion at the ISA.

Image courtesy of the Ocean Exploration Trust

The Enterprise is a not-yet-active organ of the ISA established by UNCLOS to carry out mining activities, transportation, processing, and marketing of minerals from the area. What is required for operationalization of The Enterprise should deep-sea mining begin?

Mehdi Remaoun, Algerian diplomat and former ISA African Group Coordinator, Algeria

> "
>
> First, it is worth recalling that the African Group of States made a submission to the ISA Council in 2018 regarding the operationalization of the Enterprise.This being said, the operationalization of the Enterprise is an evolving process. While the appointment of an Interim Director-General in January 2024 has established the Enterprise as an organ, its independent functioning is currently limited. This limitation was imposed by the evolutionary approach foreseen by the UNCLOS 1994 Implementing Agreement.
>
> Triggered by the start of deep-sea mining, most likely by another entity than the Enterprise, the ISA Council will issue a directive for the Enterprise's full operationalization. This directive will establish the Enterprise as an independent entity from the Secretariat and outline operational guidelines. This will be followed by the election of a 15-member Governing Board and a Director-General of the Enterprise by the ISA Assembly.
>
> The Enterprise may conduct mining operations through joint ventures or autonomously. The latter approach presents several challenges, particularly in resource mobilization and infrastructure development. Regardless of its operational approach, it must adhere to ISA regulations and environmental safeguards, like any other ISA contractor. A robust legal and regulatory framework is crucial for the Enterprise's success, ensuring its effective functioning and the equitable sharing of benefits from deep-sea mining with developing countries, as foreseen by UNCLOS and its principle of Common Heritage of Mankind.

The ISA is responsible for preventing serious harm to the marine environment arising out of deep-sea mining activities. What legal issues do you foresee if pollution from deep-sea mining affects the ocean outside of an ISA contract area?

Hannah Lily, Oceans and Natural Resources Independent Legal Consultant, UK

> “
> The ISA must take measures to prevent such pollution occurring in the first place. This is a legal requirement, and also a practical imperative given the prevailing scientific view that restoration of deep-sea ecosystems may not be possible. The ISA needs regulations and contracts that define ‘serious harm’ and ‘pollution’ and establish restrictions upon ISA contractors. Such rules should not only focus on prohibiting ‘serious harm’ but should also aspire to best environmental outcomes and practices, using measurable and science-based indicators and thresholds. For the regime to work, the ISA will need the means to verify what activities and impacts occur in practice, and to take enforcement action where there is a risk of non-compliance - before ‘serious harm’ thresholds are reached. These fundamental building blocks are not yet in place at the ISA. And are challenging to deliver via a multilateral process.
> To answer the specific question, what if pollution occurs? Firstly, we would need to acknowledge that the ISA’s regulation failed, and seek to remedy this at the systemic level before further incidents can occur. The wider risk is that the environment or third-party interests (e.g. other marine users, fish stocks) are harmed. There is a transboundary ‘do-no-harm’ principle in international environmental law, and UNCLOS also requires systems to assure prompt and adequate compensation in respect of damage caused. But for deep-sea mining it remains unclear yet precisely who would be liable, to whom, what would be actionable damages, and who would award them? It is another crucial element of the deep-sea mining regime that lacks clarity, though work is ongoing at the ISA to develop some relevant rules e.g. for a compensation fund and for contractor insurance. I would finally add that we also need to think beyond ‘effects on the ocean’ – to effects on communities, cultures, livelihoods: it’s a human rights issue as well as an environmental law issue.

Edwin Egede, Cardiff University Professor of International Law & International Relations, UK

> “
> According to Article 145 of UNCLOS and the ISA Regulations, contractors’ obligation regarding pollution is not limited to the boundaries of their contract area, but encompasses the marine environment, including ABNJ, EEZs, and other contract areas. ABNJ refers to the high seas and the Area, overlapping with the ISA’s competence to regulate pollution from deep-sea mining activities. To prevent or mitigate environmental harm in the EEZ, the ISA may adopt emergency measures if pollution from activity in the ISA contract area impacts the EEZ. This is without prejudice to such coastal state’s right to also take necessary measures to prevent or minimize serious and immediate threats to its coastline or related interests from pollution. Certain States, such as Norway, with potential to undertake deep-sea mining in their EEZ, are required to take the necessary steps to prevent, limit, and regulate marine pollution caused by such deep-sea mining activities. They must notify other States likely to be affected by the pollution, as well as competent International Organisations (IOs). Such States, according to their capabilities, and the competent IOs must cooperate to the maximum extent to eliminate the consequences of pollution and mitigate damage. Impacted states must develop and promote contingency plans dealing with such pollution incidents in the marine environment. If pollution happens in another ISA contract area, the contractors shall cooperate with the ISA and amongst themselves to respond. Issues related to contractor-to-contractor liability could arise before the Seabed Dispute Chambers for such pollution and other pollution from deep-sea mining activities based on the polluter pays principle.

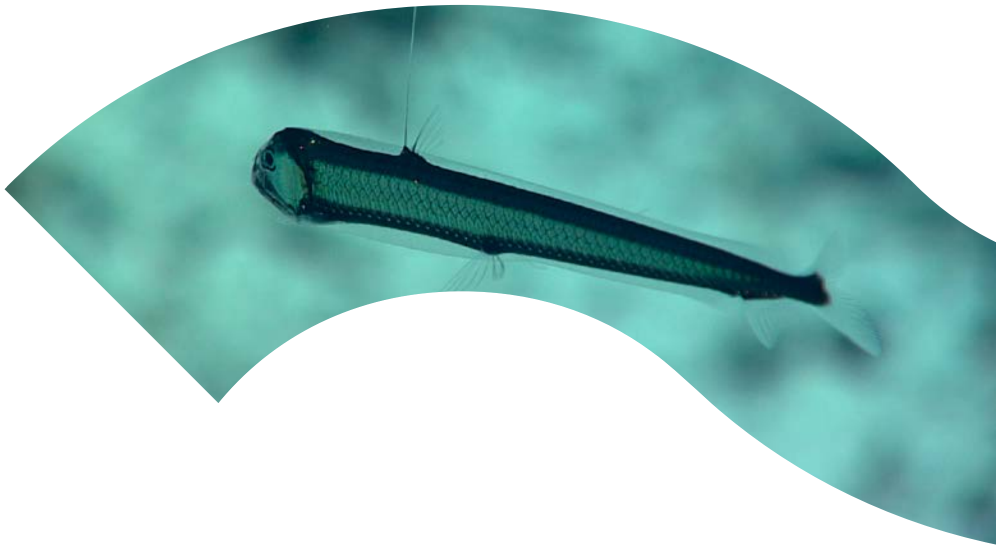


Image courtesy of NOAA Ocean Exploration

Are there additional legal considerations if countries want to pursue deep-sea mining on their Extended Continental Shelf?

Bleuenn Guilloux, La Rochelle University Junior Professor in Law of the Sea, France

> “
> Despite their sovereign rights, States parties to UNCLOS seeking to pursue deep-sea mining on their extended continental shelf (ECS) must address several legal considerations. They must comply with environmental obligations under Part XII, including the assessment of the potential effects of mining activities that may cause significant harm to the marine environment. They must respect the rights of other States, including the freedoms of navigation and scientific research in the EEZs and on the High Seas. They must share with the international community the revenues derived from the exploitation of non-living resources. These payments or contributions must be made annually through the ISA, which will redistribute them to the other States parties to UNCLOS, especially developing States. UNCLOS also promotes cooperation between States in cases of potential conflict, particularly in areas where interests overlap (e.g. fisheries, navigation and environmental protection). States with overlapping claims to ECS must negotiate to reach an equitable solution, and delimitation must be achieved by peaceful means. Interim measures, such as joint development zones, may be put in place to manage resources cooperatively while disputes are resolved. If negotiations fail, States may have recourse to the dispute settlement mechanisms provided for in Part XV. If a state’s ECS overlaps with the International seabed Area, the ISA governs mining activities in such overlapping zones until the delineation is finalised.

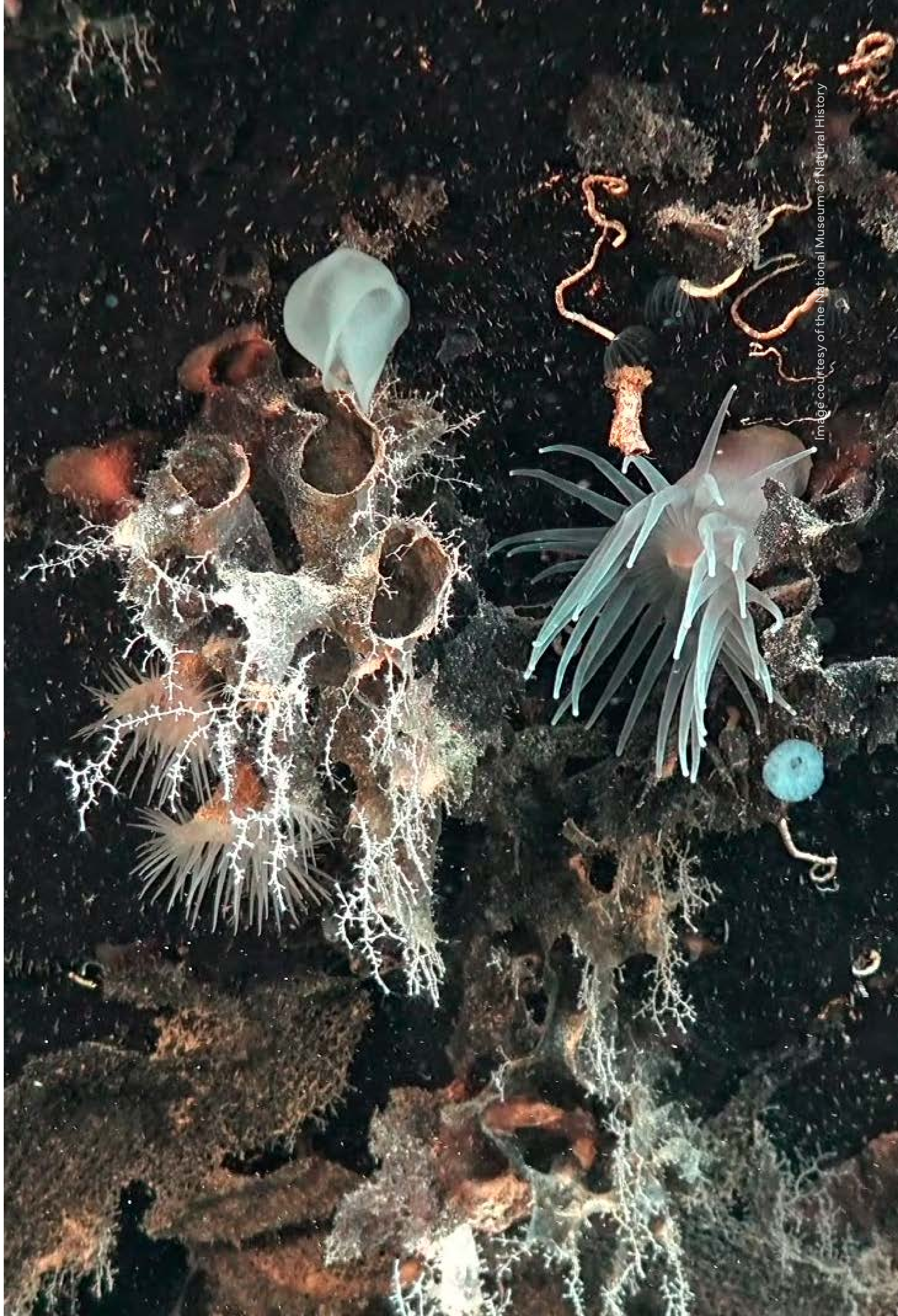


Image courtesy of the National Museum of Natural History

Many scientists, industry leaders, and countries have called for a moratorium, in which deep-sea mineral exploitation would be paused until enough scientific research has been completed to make informed decisions about whether or not we can proceed in a way that does not significantly damage deep-sea ecosystems or the geochemical cycles that regulate our planet.

If a moratorium on deep-sea mining was agreed upon, how long would you suggest it should last?

Lisa A. Levin, Scripps Institution of Oceanography, University of California San Diego Professor Emerita, USA

> “
> Should a mining moratorium be adopted, time would be required not only for additional scientific research on mining impacts and recovery potential, but for a better understanding of biodiversity structure and function, connectivity and natural variability. A reasonable initial duration would be 15 years, to enable both additional relevant baseline and applied scientific research, assessment of future societal needs for metals, and a proper discussion of the wisdom and ethics of mining, with all relevant voices heard. Even 15 years will not be sufficient time to determine the potential of some targeted ecosystems to recover, where substrate formation (e.g., nodules) can require hundreds of thousands or millions of years and animals live for centuries. The moratorium could also enable the ISA to meet its legal obligation to facilitate and disseminate marine scientific research, decoupled from mineral exploration.

If a 15-year moratorium was adopted, which scientific avenues would be the most crucial to explore during this time?

Diva Amon, SpeSeas Director & Founder, Trinidad & Tobago; Benioff Ocean Science Laboratory, University of California Santa Barbara Chief Scientist, USA

> “
> Marine scientific research, decoupled from extractive agendas, is the mechanism for unravelling the mysteries of the deep and facilitating informed decision-making and management to enable the protection of biodiversity, the marine environment, and even human rights. A moratorium or precautionary pause could facilitate this by helping to gain a better understanding of ecosystem structures, functions and services, including those of commercial and non-commercial value. Given the strong ocean connections in space and time, effective understanding will require the expansion of geographic coverage, themes beyond baseline and mining impacts to include discovery, climate change, and impacts of other human activities. Key knowledge gaps include diversity and distribution patterns, variability over time and space, life history and connectivity patterns, resilience, and ecosystem functions and services. Additional time could also be used to build inclusivity in deep-sea science by amplifying underrepresented voices and ensuring truly global teams, empower the next generation of deep-sea scientists, enable greater collaboration and cooperation between research institutions, as well as co-create with traditional and indigenous knowledge.

Image courtesy of the National Museum of Natural History

Is it possible to design "good industry practice" and "best environmental practice" rules for unproven activities such as deep-sea mining?

Elva Escobar-Briones, National Autonomous University of Mexico Senior Researcher, Mexico

Deep-sea mining activity is still building its regulatory instruments. Good industry practice and best environmental practice are inexistent, and scientific experts whose knowledge has recognized effects from deep-sea mining in ocean health have considered these. Environmental management learning from experience in established extraction industries is required.

To ensure effective protection resulting from mining harm, consultation with the deep- sea scientific community can help safeguard best environmental practice in regulations and recommendations. Stakeholder involvement can help develop regional environmental management plans and governance regimes of the common heritage of humankind. CBD's Good Practice Guidance and the International Organization for Standardization's Technical Committees may help develop good industry practice principles, standards, and tools for the yet inexistent deep-sea mining.

The effects of this industry in the ocean's remote and environmentally sensitive areas may impinge its health (loss in biodiversity, essential processes in sediment and water) including human health in a time- space large scale extractive experiment. Scientific knowledge and ethical principles are needed in the implementation of rules of unproven activities - World Medical Association's Declaration of Helsinki may be an example.

Maila Guilhon, Nippon Foundation - University of Edinburgh Ocean Voices Programme Fellow, Brazil

"

Given the current state of knowledge about deep-seabed ecosystems and the mining activities targeting them, the most effective way to approach "good industry practices" and "best environmental practices" is through the adoption of an ecosystem approach to management of human activities (EAM). EAM emphasizes the precautionary principle and acknowledges and assess the existence of uncertainties—including environmental, social, economic, and cultural— in a given context.
As a holistic framework, EAM acknowledges the intrinsic connections between environmental and social systems, often treated as separate silos by many disciplines, and thus is a tool that supports a more comprehensive understanding of complex global challenges.

At present, we lack sufficient knowledge to confidently claim the existence of best industrial or environmental practices for deep-sea mining. In light of that, the most prudent path forward for regulatory development should include broadening our perspectives on what and who will actually benefit from such industry (including by incorporating discussions on potential different views of what is a benefit) as well as suffer impacts from it in the first place. The answer to such questions requires amplifying the voices of a diverse range of stakeholders and investing in more research and capacity to deepen our understanding of the ocean and its relationships with humanity. Such efforts should not solely aim on advancing the deep-sea mining industry but instead should prioritise the consideration of alternative pathways that critically examine whether the development of this industry is desired and necessary.

The design of best environmental practices and good industry practices for deep-sea mining (if at all possible) can only progress once we have further advanced in our knowledge about the deep ocean, gathered sufficient baseline information, and obtained a better understanding of the implications of deep-sea mining in a broader context.

Do contractors hoping to mine the seafloor have the required technology ready to begin full-scale commercial mining?

Andrew D. Thaler, Blackbeard Biologic: Science and Environmental Advisors CEO, USA

> "
> Yes and no.
>
> Full-scale commercial deep-sea mining requires a complex interplay between robots operating on the seafloor, systems to carry ore to the surface and safely return waste, and shipboard support and control systems to keep everything running. Marine technology, especially complex systems designed to operate at depths exceeding 6000m with many interconnected systems, is incredibly challenging.
>
> The individual technologies necessary for deep-sea mining - the nodule collecting crawlers, the riser and lift systems, ore handling systems, and support and control systems - are well-developed and mature, but have only really been tested at small, pilot project scale. Bringing all those pieces together into a full-scale commercial operation has yet to be demonstrated and will invariably lead to the discovery of new and novel ways for the ocean to thwart even the best designed systems. That is an inevitable consequence of building technology that operates in the planet's most demanding ecosystem.
>
> All the technological pieces are there for deep-sea mining contractors, but they aren't all quite in place yet to be ready to begin full-scale commercial production, today.

Do you foresee technological advances leading towards less destructive methods of mining in the deep sea?

Hiroyuki Yamamoto, Japan Agency for Marine-Earth Science Technology Research Director, Japan

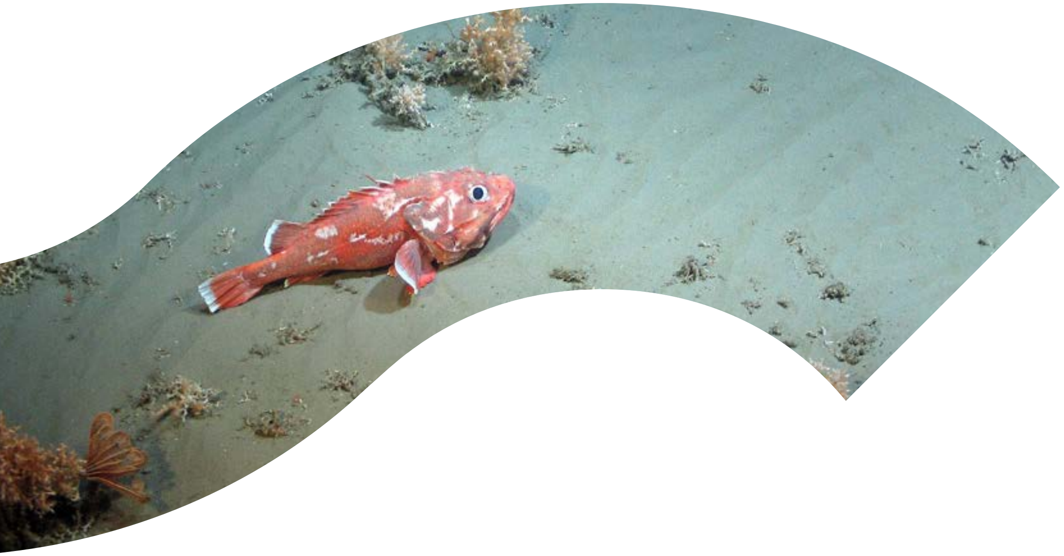
> "
> Technological development of deep-sea mining, not only in exploration methods, but also in reducing impacts such as sediment plume generation and managing operations through environmental monitoring, is progressing at national programs and venture companies. Such technological research, including machine engineering and offshore testing, should continue in any aspect of deep-sea mining. Activities in academia and private sectors provide useful knowledge and methods to learn about the deep-sea environment and to implement low-impact mining technology. While promoting the value of marine ecosystems is important, consideration should also be given to other topics, such as why we must use the marine environment and marine resources, and how we can harmonize with marine ecosystems. Innovative technologies and scientific research and development support the fundamentals for sustainable use of the marine environment, and to know the way of Nature Positive, in order to make future choices.

Image courtesy of OceanX

Image courtesy of Ifremer

After exploring the environmental, socio-economic, and legal aspects of deep-sea mining, along with the remaining uncertainties, it is important to understand if seabed mining is necessary. If land-based metal reserves can sustain the technologies required for the energy transition, that weakens several key arguments that support deep-sea mining. Additionally, deep-sea mining is not leveraged as a potential solution in any of the main scenarios for climate change mitigation.

What is the current status of land-based metal reserves and what are the forecasts of their depletion rates?



Guillaume Bertrand, BRGM (French Geological Survey) mineral resources expert and EuroGeoSurveys Mineral Resources Expert Group co-Chair, France & Belgium

“

The global demand for critical minerals continues to grow, driven by the transition to renewable energy, electrification of transportation, and other technological advancements. An examination of the current status of land-based reserves for these minerals and their depletion forecasts provides valuable insights into future supply challenges.

For manganese that is present in offshore polymetallic nodules and crusts, global land-based reserves are estimated at around 1900 million metric tons as of 2023. The major producing countries are South Africa, Gabon, and Australia, accounting for approximately 75% of global production. At current production levels, these known reserves could be depleted within the next 50-100 years. For copper that is found in offshore hydrothermal sulfurs, identified land-based reserves worldwide are approximately 1000 million metric tons as of 2023. The largest reserves are located in Chile, Australia, and Peru. Depletion forecasts suggest these known reserves could be exhausted within the next 30-50 years at current consumption rates.

Cobalt and nickel are also among the critical metals that could be found in offshore deposits. Global identified land-based cobalt reserves are estimated at 11 million metric tons as of 2023, with the Democratic Republic of the Congo holding over 50% of the world’s known reserves. Land-based nickel reserves are estimated at 130 million metric tons globally, with the largest reserves located in Indonesia, Australia, and Brazil. At current production rates, these known reserves are expected to be depleted within the next 30-60 years.

Note however that all these timelines could be affected by new discoveries and technological innovations.

As land-based mineral reserves become increasingly scarce, there is growing interest in exploring the potential of offshore deposits, particularly deep-sea nodules and hydrothermal vents, to supplement future supply. These offshore resources could provide alternative sources for manganese, copper, cobalt, and nickel, but significant technological and environmental challenges must be overcome to enable their large-scale extraction and processing.

What is the projected demand for minerals and metals present in deep-sea mining deposits? Could recycling help meet this forecasted demand?

Sandor Mulsow, Austral University of Chile Tenure Professor - Marine Geology, Chile

"

Lithium, nickel, cobalt, graphite and rare earth elements have been signaled as critical raw minerals to reach Net Zero Carbon (not Real Zero Carbon (RZC) emissions) through Announced Pledge Scenarios (APS) and States Policies Scenarios (STEPS) by 2040. The only minerals considered to be critical under current APS and STEPS which are found in manganese nodules of the seafloor are nickel, copper, and rare-earth elements (traces). The increase in demands for these critical minerals are 8% for Nickel, 3% for copper, and 14% for rare earth elements. Estimations of the entire Clarion Clipperton Zone (4.5 million square kilometers) show that only copper and nickel are in similar tonnage scale to the reserves on land today as REE are rare in deep-sea manganese nodules. Land-based mining has been able to supply the demands of copper and will continue to do so, and mining the deep-sea floor would contribute less than 3 % of projected nickel demand. From 2021 to 2024, critical minerals prices have been extremely volatile; all of them reaching lower prices compared to the mean value from 2015-2020; the exception is copper that also decreased but above the average 2015-2020. Therefore, economically deep-sea mining it is not profitable today, as it was thought in 2010.

If all land-based miners switch to green technologies, then RZC transition is possible together with recycling of long-life useful elements such as copper with a useful life of 60 years. Initiatives towards RZC emissions, real green energy extractive industries and recycling of all the demanded raw minerals will make a reality to efficiently use minerals without the unsound intervention of the deep sea.

Why has the Renault Group supported a moratorium on deep-sea mining?

Jean-Dominique Senard, Renault Chairman of the Board of Directors, France

"

The Group opted for a "Prevention rather than cure" approach. In 2022, Renault Group joined a coalition of NGOs, scientists and companies calling for a global moratorium on deep-sea mining until it can be scientifically proven that these activities can be pursued in a sustainable way. Indeed the oceans and their ecosystems play a crucial role both in regulating the climate and in generating livelihoods for women and men. Understanding of key material and financial stakes correlated to deep-sea bed mining led to Renault Group's decision to support the moratorium. The material stakes show risk of impact on the seabed from ores exploitation, with long-term consequences for ecosystems and ecosystem services. Financial stakes analysis showed that there are regulatory – such as due diligence- , business – such as recycling- , and reputational – such as clean electric transition- risks. Besides, signing the moratorium is consistent with the Renault Group environmental global policy, which includes protection of biodiversity and prioritises the circular economy, including the recycling of strategic ores such as Nickel, Cobalt, Manganese, Rare Earth. It is also consistent with the Renault Group suppliers' policy which includes respect for biodiversity and commitments for a sustainable sourcing of strategic minerals.

Image courtesy of Ifremer

As someone with extensive experience in deep-ocean exploration and venture capital, what are the primary financial risks and uncertainties you believe investors should consider when evaluating potential investments in deep-sea mining?

Victor L. Vescovo, Caladan Capital LLC Founder and CEO, USA

> “
> There is technological risk because deep-sea mining viability very much rests on a growing need, and prices for cobalt and nickel - otherwise, its business case doesn’t work. However, battery technology is moving dramatically away from electric vehicle (EV) batteries that use cobalt and nickel. Most EV batteries now made in China - lithium iron phosphate - use no cobalt or nickel, and hence have recently seen significant declines in market prices for the two metals.
>
> There are major technical risks mining 5,000 meters down with massive, rotating machinery under 5,000 psi in freezing cold, corrosive saltwater. The technical difficulties of 24/7 commercial mining of the seafloor are massively underestimated.
>
> Deep-sea mining is also based on wildly over-optimistic financial assumptions made five years ago which no longer reflect current cost levels, interest rates, or likely revenue. And legally, mining firms will be engaged in expensive, lengthy litigation which need only delay projects to make them increasingly less viable over time.
>
> Finally, relevance. Even at full production rates, The Metals Company, for example, will only produce less than three percent of worldwide nickel production. Deep-sea mining will not materially affect terrestrial mining at all, as they would have their backers believe.
>
> Deep-sea mining is an expensive, risky solution to a metal supply issue that existed fifteen years ago and does not exist now nor will in the future.

What role does art play in shaping perspectives on deep-sea mining?

TBA21, Thyssen-Bornemisza Art Contemporary, Spain

> “
> There is technological risk because deep-sea mining viability very much rests on a While science acknowledges that much of the seabed remains unknown and that the full impacts of deep-sea mining are not yet fully understood, Pacific Indigenous navigators have long recognized the seabed as kin, an interconnected space of relations that is inseparable from life itself.
>
> Art has the capacity to bring these intersecting perspectives together through which artists can critically engage with the seabed. Artists not only bring the seabed’s aesthetics to light, but also question the static notions of seabed governance and how this has shaped a far more human-centric, data-driven, territorial view of the seabed. Artists are adopting research-driven practices and aesthetics techniques, collaborating with thinkers, scientists, and indigenous worldviews. Through their work, they engage with regenerative practices, speculate consequences from seabed mining, and imagine alternative futures which includes the non-human. In doing so, they contribute to a form of knowledge beyond traditional forms of disciplines, bridging technological inquiry, imagination, and cultural narratives. This form of mediation for wider audiences is necessary as its often excluded from policy making frameworks and existing limits of seabed governance models. By embracing artistic interventions, a holistic understanding of seabed mining can emerge.

List of Questions & Participating Experts

Why is the deep sea important?
Elisa Morgera, UK
Vanessa Lopes, Cabo Verde
Kerry Sink, South Africa

As a researcher who contributed to the discovery of dark oxygen research, could you please describe what this finding means for deep-sea science and ocean exploration?
Alycia Smith, UK

Why are certain countries and companies interested in mining the deep sea?
Gideon Sarpong, Ghana

How has the narrative supporting deep-sea mining motivations shifted over time?
Peter M. Haugan, Norway

If a company or country is interested in mining the deep sea, who gets to decide if mining will progress or not?
Pradeep Singh, Malaysia

Are deep-sea mineral resources themselves important for sustaining marine biodiversity?
Anna Metaxas, Canada

The removal of deep-sea mineral resources would impact seafloor biodiversity. Would deep-sea mining impact animals beyond the seafloor?
Ricardo Serrão Santos, Portugal
Sheena Talma, Seychelles

The majority of research to understand environmental impacts has focused on the seabed itself. What are the environmental concerns surrounding a mining vessel's discharge plume into the water column?
Sergio Cambronero Solano, Costa Rica

Do we have any idea of the time and geographic scales environmental impacts from deep-sea mining would occur on?
Judith Gobin, Trinidad & Tobago
Sabine Gollner, The Netherlands

Could deep-sea environments and species recover from the environmental impacts of deep-sea mining?
Baban Ingole, India

What ethical concerns exist surrounding deep-sea mining?
Endalew Lijalem Enyew, Norway

What are the concerns among fishers and the seafood industry surrounding deep-sea mining?
Transform Aqorau, Solomon Islands

As a member of the Ngati Raina tribe, what does your community think about the prospect of deep-sea mining?
Alanna Matamaru Smith, Cook Islands

Under UNCLOS, states must preserve deep-sea ecosystems for future generations. As an ocean youth representative, what are your thoughts on deep-sea mining?
Sophia Laarissa, Morocco
Houangninan Midinoudewa, Benin

How can we progress deep-sea ecosystem assessments to help put a monetary figure on the natural capital (economic value provided by natural resources) of the deep sea?
Torsten Thiele, Germany

Who stands to benefit from deep-sea mining, and what would those benefits be?
Jonathon Moses, Norway

The ISA is mandated to facilitate benefit sharing of profits gained from deep-sea mining, but the costs (including to the marine environment) are likely to significantly exceed any financial benefits. How can an agreed-upon payment mechanism or benefit-sharing mechanism reflect this reality appropriately?
Nathalie Hilmi, Monaco

There are pre-existing international agreements such as The United Nations Agreement on Biodiversity Beyond National Jurisdiction (BBNJ) and the Convention on Biological Diversity (CBD). How would deep-sea mining in international waters interact with these agreements?
Bobbi-Jo Dobush, USA

If deep-sea mining were to progress, who would pay for and carry-out the long-term environmental assessments outside the contractor areas according to standards, and what metrics would be used to track impacts and harm?
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Edwin Egede, UK

Are there additional legal considerations if countries want to pursue deep-sea mining on their Extended Continental Shelf?
Bleuenn Guilloux, France

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Lisa A. Levin, USA

If a 15-year moratorium was adopted, which scientific avenues would be the most crucial to explore during this time?
Diva Amon, Trinidad & Tobago

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Maila Guilhon, Brazil

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Andrew D. Thaler, USA

Do you foresee technological advances leading towards less destructive methods of mining in the deep sea?
Hiroyuki Yamamoto, Japan

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Guillaume Bertrand, France

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Sandor Mulsow, Chile

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Victor L. Vescovo, USA

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TBA21 Thyssen-Bornemisza Art Contemporary, Spain

This work was led by Bruno David and Françoise Gaill after a request from the French President Emmanuel Macron.

The Global Deep-Sea Consultation was led by Elva Escobar-Briones & Ricardo Serrão Santos.

Scientific Committee Members

Diva Amon
Sergio Cambronero
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Judith Gobin
Bleuenn Guilloux
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Pradeep Singh
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Hiroyuki Yamamoto

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