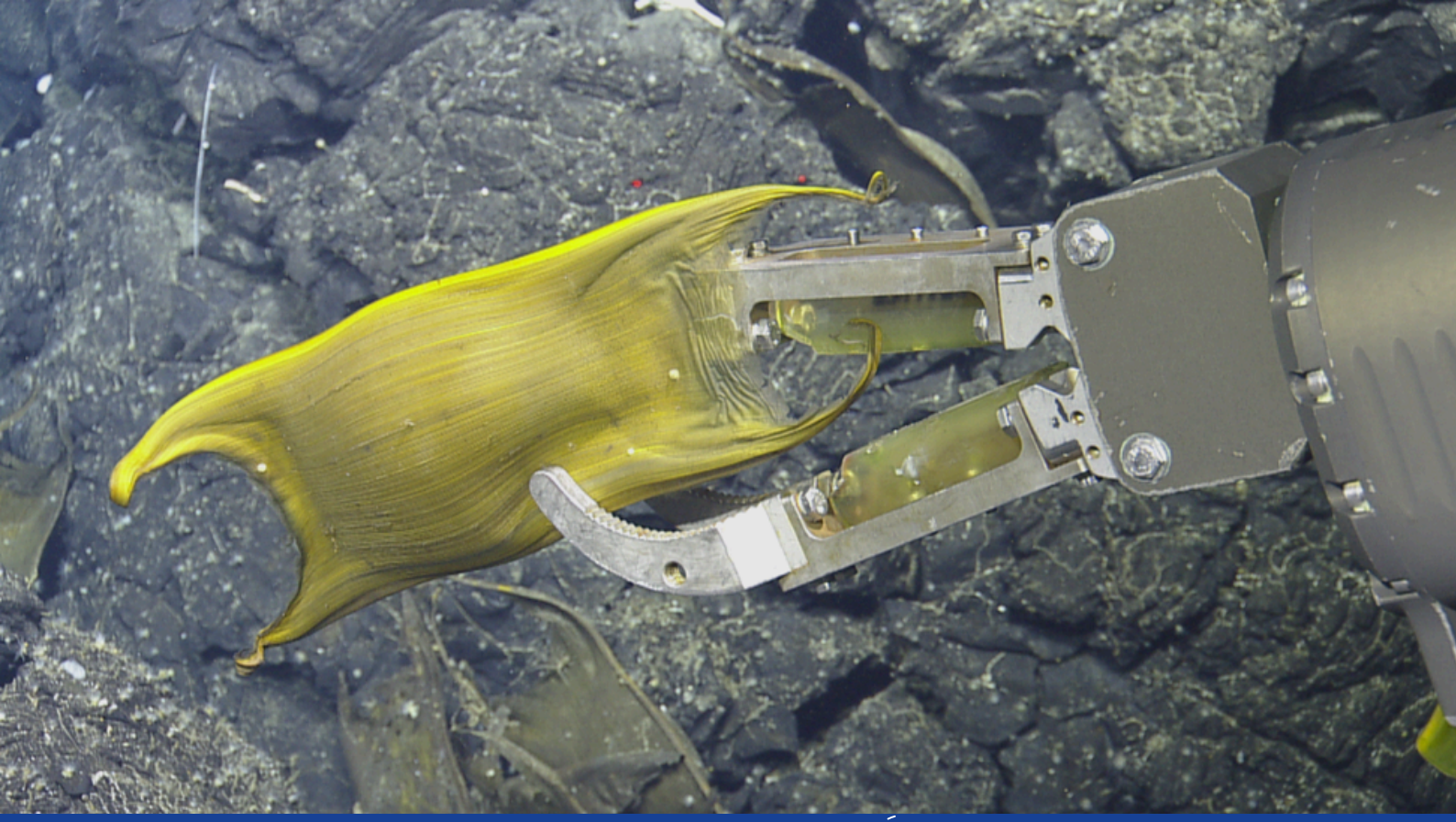

CMS

Convention on the
Conservation of Migratory
Species of Wild Animals

IMPACTS OF DEEP-SEA MINING ON MIGRATORY SPECIES: REVIEW AND KNOWLEDGE GAPS

CMS Technical Series Publication No. 53

Impacts of Deep-sea Mining on Migratory Species: Review and Knowledge Gaps

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A skate egg case collected from a polymetallic sulphide deposit in the Galápagos Islands. Image via Ocean Exploration Trust

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Executive Summary

Deep-sea mining is the process of extracting ore from polymetallic sulphides, cobalt-rich crusts and polymetallic nodules, typically at depths ranging from 1,000 to 6,000 metres. Deep-sea mining is a nascent industry; it faces multiple legal, technical and environmental hurdles if it is to enter into commercial production. In areas beyond national jurisdiction (ABNJ), the industry is overseen by the International Seabed Authority (ISA), a UN entity tasked with both regulating all mineral-related activities and ensuring the protection and preservation of the marine environment from these activities.

The impacts of deep-sea mining on the marine environment are not well understood and will vary across taxonomic groups and ecosystem types. Research to date has prioritized impacts to the seafloor ecosystems directly targeted by mining interests. There has been less focus on the broader ocean environment and, in particular, the pelagic realm. This includes the impacts to highly migratory species[1] that move through potential mining sites and adjacent impacted areas, that interact with prey species and habitats associated with mining sites, and that rely on acoustic and chemical cues to migrate across the ocean.

Here, we assess the current state of knowledge regarding the potential impacts of deep-sea mining on migratory species, focusing on those listed under the Convention on the Conservation of Migratory Species of Wild Animals (CMS), while also considering other important migratory species not listed under CMS.

Of the CMS-listed marine species, 48% of marine mammals, 38% of sharks and rays, 56% of marine reptiles, and 4% of bony fish have ranges that overlap with potential or proposed deep-sea mining sites. Of the CMS-listed bird species, 7%, including most major seabird groups, also have ranges that overlap with these sites.

Major potential impacts from deep-sea mining on migratory species include: (1) the production of plumes at the seafloor, in the midwater and possibly at the ocean surface resulting in the smothering of seafloor habitat, disruption of chemical cues, disturbance to navigation and alteration of prey behaviour; (2) chronic, long-term noise that alters the acoustic environment and may interfere with echolocation, communication, navigation and other soniferous behaviours; (3) increased presence of mining support vessels and equipment that could alter animal behaviour – e.g., by changing habitat use, attracting prey species or creating light pollution; (4) increased vessel traffic in previously low-traffic areas resulting in a higher risk for vessel strikes and, consequently, a higher risk of injury or death; (5) destruction of habitats of ecological significance – e.g., nursery or foraging grounds – potentially leading to loss of habitats critical to the survival of migratory species.

Significant knowledge gaps exist for all potential impacts of deep-sea mining on migratory species. The potential for severe, irreversible impacts on biodiversity, ecological connectivity and species behaviour calls for restraint and rigorous assessment before any exploration and exploitation activities proceed. Given the current gaps in scientific understanding of how deep-sea mining may affect migratory species, a precautionary approach is essential. In the absence of comprehensive knowledge, precaution ensures that environmental integrity is prioritized, safeguarding species whose life cycles and habitats remain only partially understood.

Climate change-induced range shifts may substantially alter migration patterns of some migratory species in the near future, creating additional unknowns about the spatiotemporal overlap of this nascent industry. This will require ongoing reassessment of the impacts of deep-sea mining, including synergistic or cumulative impacts, on certain species over time.

Recent Relevant Documents from Intergovernmental Bodies

At the 14th Meeting of the Conference of the Parties, the CMS Secretariat presented UNEP/CMS/COP14/Doc.27.2.4/Rev.1,[2] a document that raised concerns over the potential negative impacts of deep-sea mining on migratory species and their habitats, as well as proposed draft resolutions and decisions. It documented the difficulty in acquiring baseline data from deep-sea mining sites, and the limited scientific knowledge available for these sites and their associated biodiversity and ecosystems.

The potential impacts identified in UNEP/CMS/COP14/Doc.27.2.4/Rev.1 include the direct destruction of benthic habitats, injury of marine species by exploratory or commercial mining operations, smothering, preventing communication and feeding, toxic effects from sediment plumes, and loss or alteration of biodiversity. Indirect or secondary impacts include disturbance caused by increased noise and light pollution. These impacts could have broad ecological effects that impact entire food webs beyond the spatial and temporal limits of the

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1 Article I (1)(a) of the Convention on the Conservation of Migratory Species of Wild Animals (CMS) defines migratory species as: "the entire population or any geographically separate part of the population of any species or lower taxon of wild animals, a significant proportion of whose members cyclically and predictably cross one or more national jurisdictional boundaries."

2 Deep-sea mining: https://www.cms.int/en/document/deep-sea-mining

mining operation. The document notes the particular impact of noise and light pollution on cetaceans.

CMS COP14 Decision 14.52 requested the Scientific Council to "develop a report on the state of knowledge of the impacts of deep-seabed mineral exploitation activities on migratory species, their prey and their ecosystems, including identifying knowledge gaps that should be addressed."

The International Whaling Commission (IWC) convened an intersessional correspondence group on deep-sea mining to assess the industry's potential impact on cetaceans.[3] The IWC report concluded that direct impacts on cetaceans from deep-sea mining will most likely come from noise generation, of which there is an abundance of data from other maritime activities. The report also identified potential indirect impacts from sediment plumes, ecosystem disruption and disturbance of prey species.

The IWC Scientific Committee recommended that the IWC join the call for a moratorium on deep-sea mining to allow for more study of potential environmental impacts, and for the IWC to collaborate with other international bodies, including CMS, regarding the impact of deep-sea mining on marine animals and ecosystems, along with research recommendations for future studies.

In May 2025, the UN Secretary-General's Scientific Advisory Board also released a brief highlighting the uncertainty surrounding the environmental impacts of deep-sea mining. They recommended applying the precautionary principle and developing a comprehensive scientific assessment of impacts and environmental goals as well as definitions of environmental harm, evaluating the need for deep-sea mining, and promoting alternative mineral production strategies to reduce reliance on new extraction.[4]

Deep-Sea Mining

Deep-sea mining (DSM) is the process of extracting ore from the seafloor beyond the limits of the continental shelf, and typically occurs at depths of between 1,000 and 6,000 metres. While different stakeholders use terms like deep-seabed mining or deep seabed mineral exploitation to capture specific aspects of the proposed industry, we here use the term 'deep-sea mining' to refer to the exploration and exploitation of three ore types – polymetallic sulphides, cobalt-rich crusts and polymetallic nodules – from the deep ocean. These ores are extracted using a variety of proposed techniques that would have different impacts on the seafloor, water column and surface. These deposits predominantly occur on the seabed in areas beyond national jurisdiction (ABNJ). Roughly 81% of polymetallic nodules, 56% of polymetallic sulphides and 46% of cobalt-rich crusts are found in ABNJ (Petersen et al., 2016).

Polymetallic sulphides are created by the geochemical activity of hydrothermal vents (fissures in the deep seafloor where seawater is ejected from a series of stockworks as chemically enriched superheated plumes). They are found throughout the planet's oceans at active plate margins, back-arc basins and volcanic hotspots. This hydrothermal fluid contacts cold seawater causing suspended heavy metals to precipitate out of solution, where they are deposited on the walls to form a growing hydrothermal vent chimney. Polymetallic sulphides are rich in precious metals like copper, gold and nickel, as well as iron, zinc, lead and barium.[5] Polymetallic sulphides are the smallest, in area, of the deep-sea deposits. The total surface area of active hydrothermal vent fields globally is roughly equivalent to the island of Manhattan (approximately 50 km^2; Menini and Van Dover, 2019), with those fields producing polymetallic sulphides representing a subset of that area. Polymetallic sulphides are relatively common around the Pacific Ring of Fire, Central Indian Ridge, East Pacific Rise and Mid-Atlantic Ridge (Thaler and Amon, 2019).

Cobalt-rich crusts (also referred to as ferromanganese crusts) are thick, metal-rich crusts that form on the exposed sides of seamounts. They accrete on the hard substrate exposed by ocean currents on the flanks of seamounts, where minerals precipitate out of seawater over millions of years (He et al., 2011). Cobalt-rich crusts are among the shallowest forming deposits targeted for exploitation, occurring at a depth of between 400 and 4,000 metres. Deposits contain as much as 2.5% cobalt (Hein et al., 1986), as well as other critical metals such as titanium, tellurium, nickel, manganese, platinum, scandium and other metallic rare-earth elements (Roberts, 2000). These crusts can be up to 25 centimetres thick, with some estimates placing the total surface area of cobalt-rich crusts at nearly 2% of the seafloor.[6]

Polymetallic nodules are the most abundant and broadly distributed of the deep-sea ores. Originally referred to as manganese nodules, these small, potato-sized accretions are scattered across the abyssal plain at depths of between 3,500 and 6,500 metres. Polymetallic nodules are rich in manganese, cobalt, nickel and copper (Kuhn et al., 2017). Unlike other deposits, these nodules

[3] Report of the Intersessional Correspondence Group on Deep-Sea Mining: https://archive.iwc.int/pages/view.php?ref=22070

[4] Brief of the Scientific Advisory Board on: Deep-sea Mining: https://www.un.org/scientific-advisory-board/en/deep-sea-MINING

[5] Seabed Mining in Areas Beyond National Jurisdiction: Issues for Congress: https://crsreports.congress.gov/product/pdf/R/R47324

[6] ISA Report on Cobalt-Rich Crusts: https://www.isa.org.jm/wp-content/uploads/2022/06/eng9.pdf

sit on top of the sediment. Nodules accumulate over millions of years as metals from the surrounding seawater accrete around a nucleating agent like a shark's tooth, pteropod shell, bone, diatom test or other small, hard object (Wang et al., 2012). The chemical process that promotes nodule formation is not well understood, but some studies suggest that nodule formation is mediated by microorganisms which drive biomineralization (Wang et al., 2009).

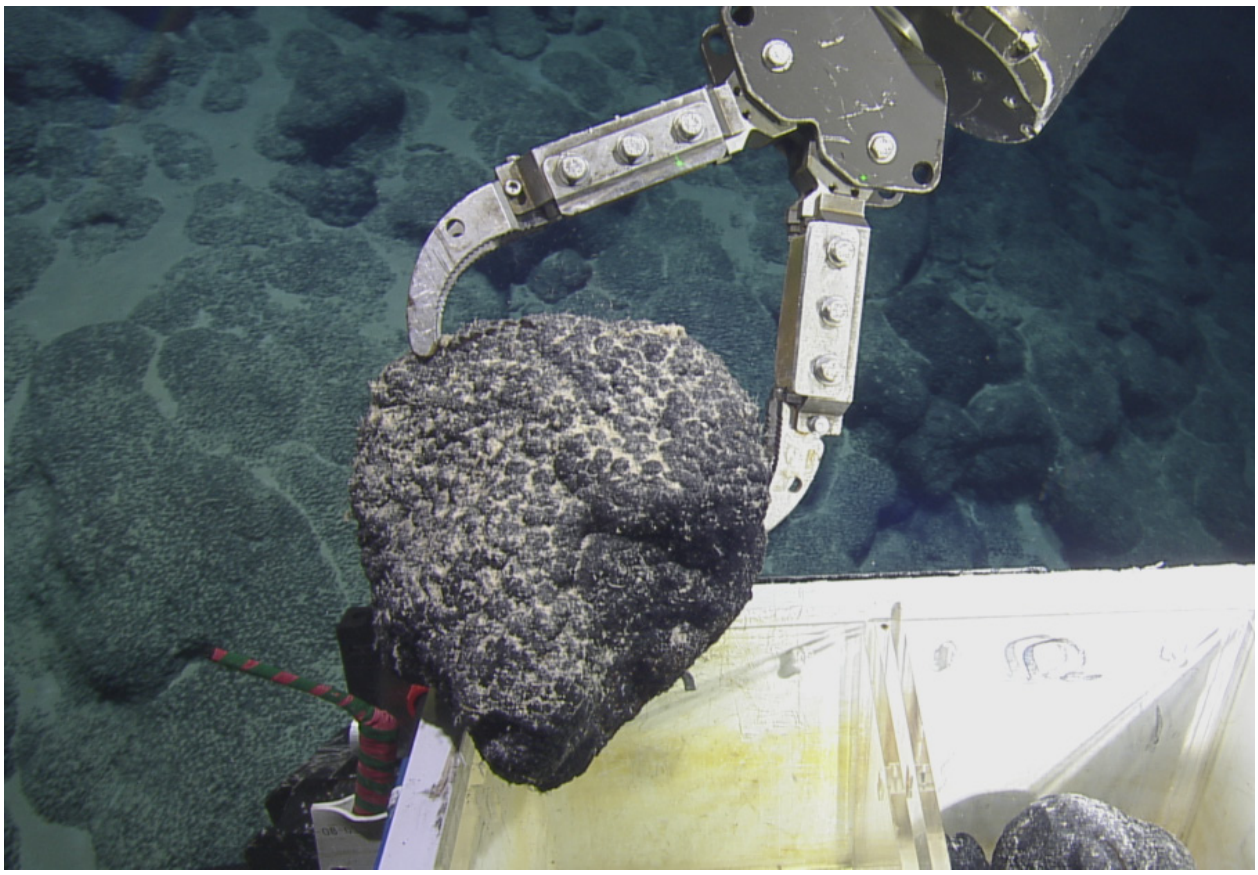
Other mineral deposits are also potential targets for deep-sea mining, including rare-earth element enriched mud and marine phosphorites. These deposits may occur in regions generally considered the deep sea. Rare-earth element enriched muds can occur on the deep seafloor offshore of rivers' alluvial plains, where metals suspended by erosion are deposited in the deep ocean. These muds can be rich in neodymium, molybdenum, yttrium and other rare elements that are used in small quantities in modern electronics (Tanaka et al., 2020). Phosphorites form on the seafloor and contain many agriculturally important minerals. They were a source of speculation towards the end of the 20th century but have received limited attention in recent years (Hein et al., 2016).

While these other mineral deposits may become targets for deep-sea mining in the future, as it is currently structured, the International Seabed Authority – the UN agency tasked with regulating all mineral-related activities in areas beyond national jurisdiction – is predominately concerned with the exploration and exploitation of polymetallic sulphides, cobalt-rich crusts and polymetallic nodules.

Proposed Mining Technologies

Deep-sea mining technologies, particularly those used for polymetallic-nodule extraction, have evolved over the past 50 years. The original mining tools developed in the early 1970s consisted of a system of bottom trawls and sled-based collectors that were dragged across the seafloor by a support ship. The industry is now primarily focusing on tracked benthic crawlers and, in the case of one company, buoyant autonomous vehicles. Tracked vehicles use riser and lift systems to deliver ore to a surface ship, whereas autonomous vehicles employ onboard hoppers that store ore prior to recovery to the surface.

Unlike other deep-sea ores, polymetallic nodules have no overburden (sediment or mineral deposits that cover the ore and must be removed to access the ore beneath). The ore does not need to be mechanically broken at the seafloor. Nodules are either stored on the collector vehicle until return to the surface or transferred to a riser and lift system, which pumps whole nodules to the surface vessel for processing aboard a ship or at a land-based ore refinery. These nodules are dewatered



Picture 1. Sampling a ferromanganese crust in Johnson Atoll. © Ocean Exploration Trust/NOAA

and the sediment and water slurry released overboard, either at the seafloor collection site, in the midwater or at the surface – depending on the proposed mining system and any future regulatory requirements that are developed.

As of June 2025, three major private commercial mining contractors have begun formal testing of their seafloor production tools: The Metals Company (TMC), Impossible Metals and Global Sea Mineral Resources (GSR). State-owned or co-owned mining contractors, including JOGMEC (Japan) and COMRA (China), have also conducted early pilot tests. Other countries actively exploring the potential for deep-sea mining, including India and the Republic of Korea, have begun developing deep-sea mining capacity but the status of any initial commercialization tests are not publicly available. It should be noted that none of these tests have been conducted at the scale or intensity of commercial mining.

TMC is a Canada-based multinational with three ISA exploration leases in the Clarion-Clipperton Zone (CCZ) as well as a pending exploration permit application with the United States for work in the CCZ. Allseas provides vessel and logistical support. TMC intends to use a tracked crawler with a suction system to collect nodules from the seafloor into a hopper, which are then pumped through an over 4-km-long riser and lift system that delivers the nodules to a surface vessel.[7]

Impossible Metals is a US-based company which has a pending lease application with the United States of America for work in the American Samoa Exclusive Economic Zone (EEZ). Impossible Metals intends to use a fleet of autonomous vehicles that collect nodules using machine-learning-guided arms to selectively collect nodules from the seafloor. Nodules are stored locally in a hopper and the entire vehicle cycles between the surface and the seafloor to deliver nodules to the production support vessel.

GSR is a Belgium-based subsidiary of Dredging, Environmental and Marine Engineering NV (DEME) Group, one of the world's leading dredging operators. GSR has ISA-issued exploration leases in the Clarion-Clipperton Zone. GSR intends to use a similar system to TMC, with a tracked crawler operating a suction system to collect nodules from the seafloor and then transport them through a riser and lift system to a surface vessel.

Several ISA Member States are in the process of developing and testing their own seafloor production tools, including China, Japan, the Republic of Korea and India. Of these, Japan has the most extensive testing programme for deep-sea mining equipment, having completed pilot studies on the commercial mining of polymetallic sulphides[8] and cobalt-rich crusts,[9] both of which were noted as 'world's first' developments. Japan is currently engaged in a pilot programme to extract rare-earth elements from deep marine muds.[10] China has also developed a tracked mining vehicle designed to collect polymetallic nodules from the seafloor in pilot studies.[11]

Polymetallic sulphides and cobalt-rich crusts present additional challenges. Unlike polymetallic nodules, the ore is part of the seafloor substructure, with accumulated overburden. One company, Nautilus Minerals, attempted to develop a polymetallic sulphide mining prospect in the territorial waters of Papua New Guinea. Nautilus intended to use three large tracked remotely operated vehicles (ROVs) working in tandem to flatten the topography of the mining site, reduce the ore into manageable chunks, and pump the ore to the surface using a riser and lift system.[12]

As no commercial deep-sea mining has yet taken place, the specific technologies used to collect seabed mineral resources, deliver them to the surface and discharge waste products may ultimately differ from current proposed mining systems.

The International Seabed Authority

The International Seabed Authority (ISA) is a UN entity comprised of UN Convention on the Law of the Sea (UNCLOS) Member States (all of which have the "obligation to protect and preserve the marine environment" under UNCLOS Article 192) and Observers as well as an administrative organ, the ISA Secretariat, tasked with both promoting the development of the

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7 The Metals Company completes a world-first test of deep-sea mining system': https://dsmobserver.com/2022/12/the-metals-company-completes-a-world-first-test-of-deep-sea-mining-system

8 Japan First to Test-Mine Hydrothermal Deposit': https://dsmobserver.com/2017/10/japan-first-mine-hydrothermal-deposit/

9 JOGMEC Conducts World's First Successful Excavation of Cobalt-Rich Seabed in the Deep Ocean; Excavation Test Seeks to Identify Best Practices to Access Essential Green Technology Ingredients While Minimizing Environmental Impact': https://www.jogmec.go.jp/english/news/release/news_01_000033.html

10 Japan to test deep sea mining amid public and scientific concern': https://oceanographicmagazine.com/news/japan-to-test-deep-sea-mining-amid-public-and-scientific-concern/

11 Chinese deep-sea mining vehicle that could put entire South China Sea in reach tested': https://www.scmp.com/news/china/science/article/3270047/chinese-team-tests-deep-sea-mining-vehicle-could-put-entire-south-china-sea-reach

12 The secret on the ocean floor': https://www.bbc.co.uk/news/resources/idt-sh/deep_sea_mining

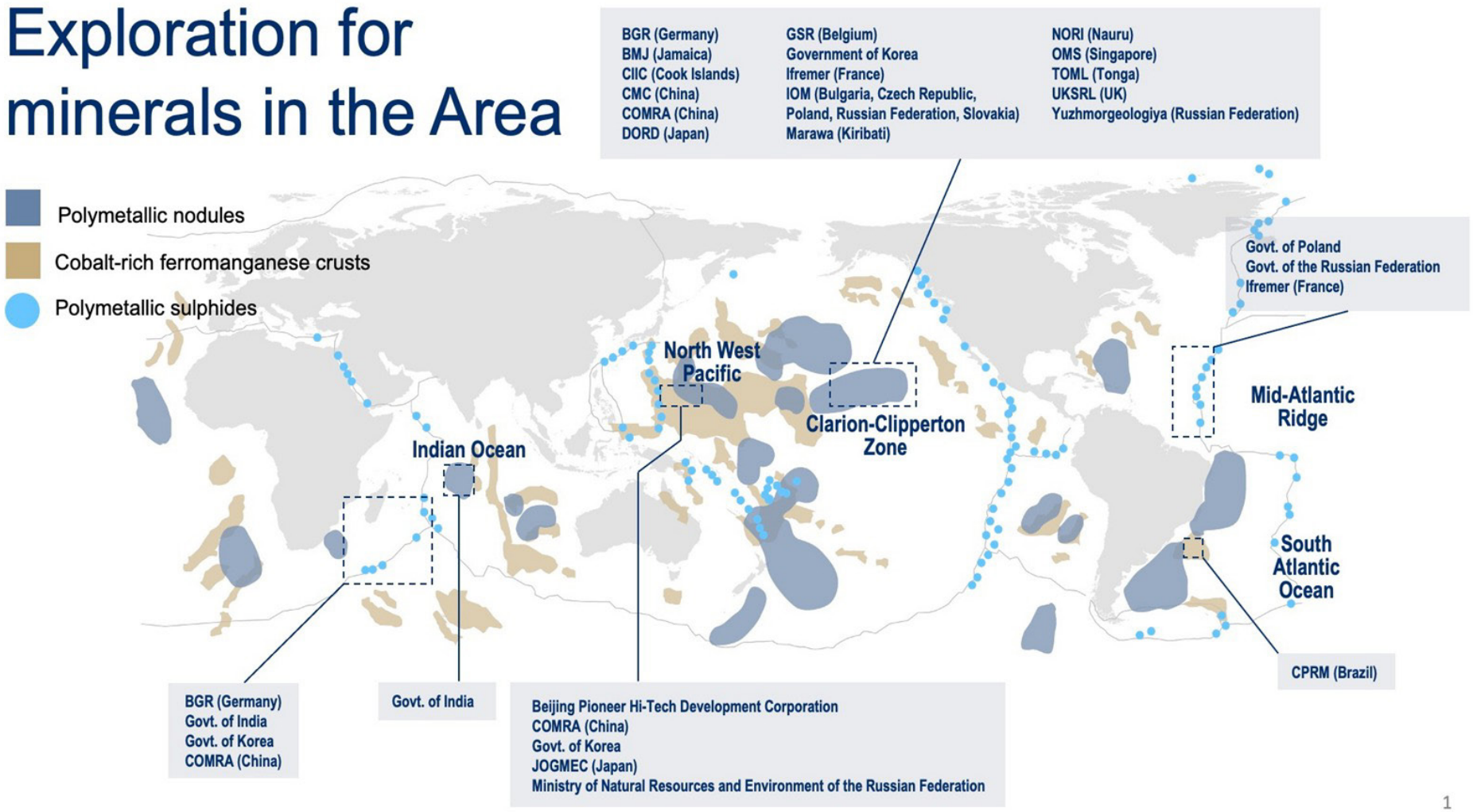

Figure 1: Location of seabed mineral resources and ISA issued mining leases.

deep-sea mining industry and protecting the marine environment. The Secretariat is overseen by the ISA Secretary-General.

The ISA is comprised of three decision-making bodies: the Legal and Technical Commission, the Council, and the Assembly. The Legal and Technical Commission consists of subject matter experts who review reports and plans of work from mining contractors, and provide recommendations to the Council. The Council, a rotating group of 36 Member States that reflect the geographic and economic diversity of the ISA, reviews reports from the Legal and Technical Commission and Secretariat, and provides recommendations to the Assembly. The Assembly, comprised of all ISA Member States, is the ultimate decision-making body within the ISA.

The ISA recognizes Observers, including stakeholder groups, NGOs and members of civil society, whose constituency may be impacted by the development of deep-sea mining. Observers are able to intervene during negotiations and participate in the development of rules and regulations but are not empowered to vote on proposals. There have been concerns over inclusion and transparency during these negotiations (Ardron et al., 2023; Jaeckel et al., 2023). While mining companies (contractors) do not participate directly in voting, they may make their preferences known through their sponsoring States and are invited to participate in the development of rules and regulations.

ISA DeepData Portal

The ISA maintains the Deep Seabed and Ocean Database (DeepData). DeepData is intended to serve as a geospatial data management system that hosts environmental data collected by deep-sea mining contractors during their exploration activities. Mining contractors are required to submit their data from exploration activities through the database. Publicly available data is cross-archived through the Ocean Biodiversity Information System (OBIS).[13]

However, an independent analysis of DeepData found evidence of extensive duplication of datasets, an absence of unique record identifiers and significant taxonomic data–quality issues, compromising the quality of the data (Rabone et al., 2023, 2022). While the publication of DeepData records on the OBIS ISA node in 2021 led to large-scale improvements in data quality and accessibility, a number of serious issues persist on both platforms restricting usability of the data.

An assessment, as part of this report, of the ISA's DeepData portal and the associated database uploaded to the OBIS, revealed a paucity of surface observations conducted by deep-sea mining contractors. The archive contains observations of only eight cetaceans, three birds, one shark and one bony fish (the latter two at a depth of less than 200 metres). Among all the contractor-supplied environmental observations, only three marine reptile observations were reported; moreover, the marine reptiles appear to have been mischaracterized as birds. No detailed taxonomies (i.e. genus or species classification) were supplied for any reported taxa.

A single ISA mining contractor (TMC) supplied hydrophone recordings of cetaceans, both at shallow and deep-water moorings from within their mining contract area in the CCZ. Four separate delphinid whistles were recorded over a half-month period from the deep-water hydrophone array. The shallow water hydrophone array recorded delphinid whistles and click trains, sperm whale clicks, and minke whale calls, suggesting that marine mammal interactions within deep-sea mining contract areas may be more frequent than suggested by the existing sparse observational data.

Deep-Sea Mining in National Waters

Papua New Guinea is the only country to have issued a mining exploitation lease, granting permission to the now defunct Nautilus Minerals to mine Solwara I.[14] The rise and fall of Nautilus Minerals provides a fascinating insight into the economic and political challenges of mining a deep-sea hydrothermal vent – one that is beyond the scope of this report.[15] Results from Nautilus-funded research demonstrate that Papua New Guinea's hydrothermal vents connect vent communities in the northern and southern West Pacific (Tunnicliffe et al., 2023).

Japan has engaged in experimental deep-sea mining within its own EEZ, extracting ore from seafloor massive sulphides, cobalt-rich crusts and polymetallic nodules. Deep-sea mining priorities for Japan were set by the 2007 Basic Plan on Ocean Policy, which defined plans for commercialization of seabed resources (Okamoto et al., 2018). Beyond the three main deep-sea mineral resources, Japan has also engaged in significant research into the extraction of rare-earth element (REE) enriched muds that occur within the country's EEZ (Kato et al., 2011). The REE enriched muds can provide a valuable source of extremely rare critical metals (Takaya et al., 2018).

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13 OBIS ISA: https://obis.org/node/9d2d95be-32eb-4d81-8911-32cb8bc641c8

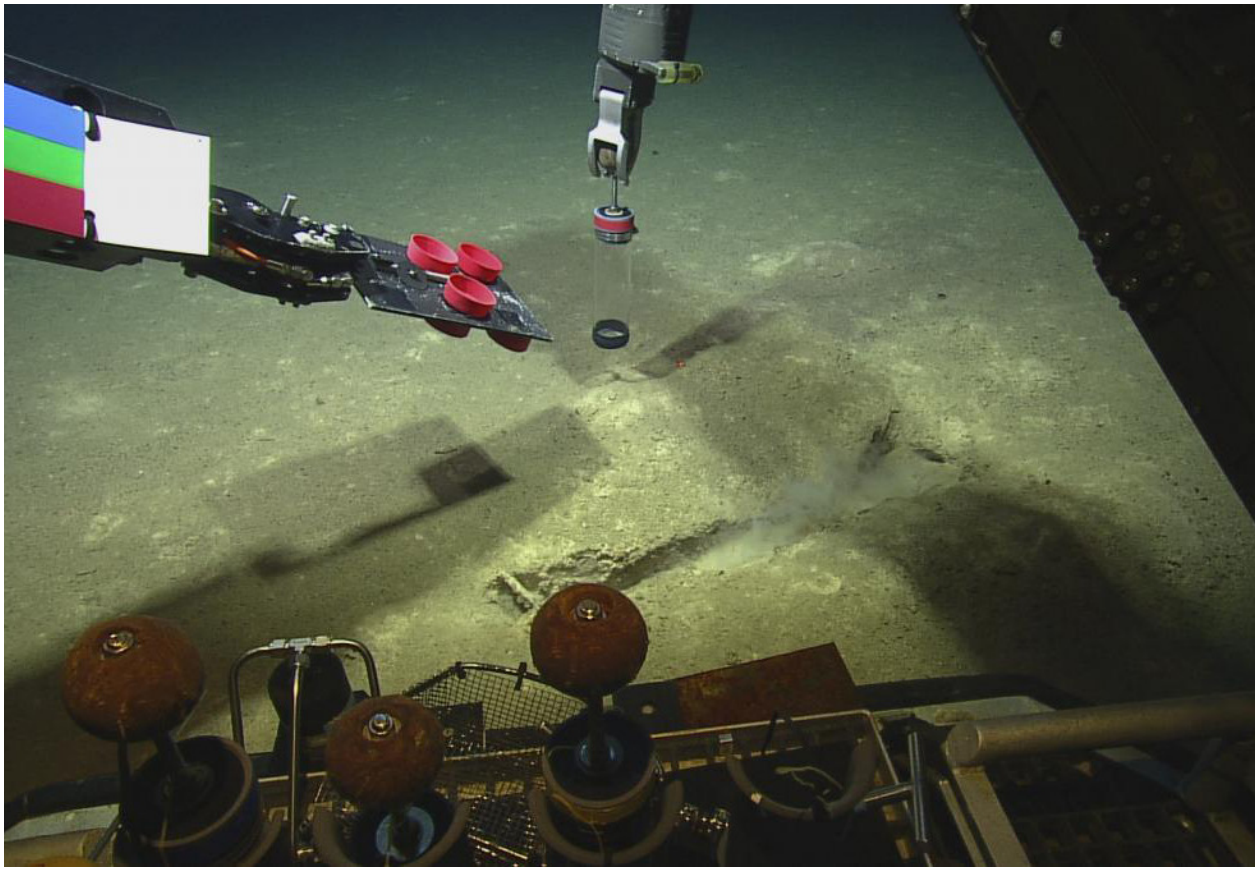
14 Environmental Impact Statement – Solwara I Project - https://dsmobserver.com/wp-content/uploads/2017/05/Environmental-Impact-Statement-Executive-Summary-English-1.pdf

15 The last days of Nautilus Minerals: https://dsmobserver.com/2020/05/the-last-days-of-nautilus-minerals/

New Zealand is unique among ISA Member States in that, while it has backed a 'conditional moratorium' on deep-sea mining in ABNJ (which calls for a moratorium on the commercialization of deep-sea mining until the Mining Code is approved by the ISA),[16] it has resisted doing so in New Zealand waters. A bill to ban deep-sea mining in New Zealand's EEZ was defeated in early 2023.[17] As with many cases of deep-sea mining in national waters, New Zealand's approach reflects a greater diversity of potential mineral resources than those under consideration by the ISA, and includes hydrocarbons, iron-rich sands and phosphorite nodules (Ellis et al., 2017), as well as polymetallic nodules, polymetallic sulphides and cobalt-rich crusts.

Norway has explored pursuing deep-sea mining within its own territorial waters. In December 2023, Norway's Parliament announced that they had reached a deal to open up Norwegian waters in the Arctic for deep-sea mining exploration, a necessary first step in the commercialization of deep-sea mining.[18] While this move does not immediately allow Norwegian contractors to begin mining seafloor massive sulphides and cobalt-rich crusts in the Arctic, many NGOs and stakeholder groups view this, in conjunction with Norwegian mining start-up Loke Marine's recent acquisition of UK Seabed Resources Ltd. from Lockheed, as a strong signal that Norway intends to begin mining in its own waters in the immediate future. The effort to open up Norwegian waters to exploration was suspended as part of a parliamentary budget dispute at the end of 2024, and the mining contractor, Loke Marine, has since entered into bankruptcy.[19]

The Cook Islands were among the first Pacific Nations to pass laws regulating access to seabed mineral resources within its EEZ. It was the first country to establish a Seabed Minerals Authority and pass a series of Seabed Minerals Acts culminating with the current Seabed Minerals Act of 2019 to regulate the nascent



Picture 2. Potential feeding gouge caused by an unidentified beaked whale. © Ocean Exploration Trust/NOAA

16 NZ backs conditional moratorium on seabed mining in international waters': https://www.beehive.govt.nz/release/nz-backs-conditional-moratorium-seabed-mining-international-waters

17 Bid to ban deep sea mining defeated: 'Our community don't want it. The public doesn't want it': https://www.rnz.co.nz/news/political/489658/bid-to-ban-deep-sea-mining-defeated-our-community-don-t-want-it-the-public-doesn-t-want-it

18 Deep-sea mining in the Arctic Ocean gets the green light from Norwegian lawmakers': https://apnews.com/article/norway-underwater-mining-arctic-663c7fceba5fc41e84affc5f84d52504

19 A Miner Goes Bust, Another Goes Solo as Progress on U.N. Seabed Rules Stalls': https://www.wsj.com/articles/a-miner-goes-bust-another-goes-solo-as-progress-on-u-n-seabed-rules-stalls-cba45638

industry. While the Seabed Minerals Act governs how contractors can explore and exploit the deep waters around the Cook Islands, environmental issues fall under the aegis of the 2003 Environment Act. The Cook Islands has also implemented a suite of holistic marine spatial management tools (Petterson and Tawake, 2019).

The Kingdom of Tonga has also been actively pushing to advance deep-sea mining within its own waters. Tonga passed its Seabed Mineral Act in 2014, which stipulates a vetting process for mining contractors and a public consultation phase for any potential exploitation, mandates environmental impact assessments, and provides the government with enforcement powers over mining contractors.[20] Tonga's Seabed Minerals Act also dictates how the Kingdom of Tonga oversees the mining contractors it sponsors operating in the Area.

The United States has recently issued an executive order to expedite permitting processes under the Outer Continental Shelf Land Acts and the Deep Seabed Hard Minerals Resources Act.[21] This could result in the United States entering into deep-sea mining agreements in both national and international waters. However, it is not yet clear the extent to which it will participate in deep-sea mining.

Deep-Sea Mining Impacts

Deep-sea mining presents a challenging case study into the impacts of an emerging extractive industry. Because the development of deep-sea mining has been overseen by the ISA since 1994, it is a rare example of an industry in which environmental regulation has, so far, preceded industrial exploitation. This has resulted in a curious paradox: research has been conducted to help determine the baseline environmental conditions of the deep seafloor – there was even a small cohort of long-term disturbance studies conducted in the 1970s and 1980s – but because no commercial deep-sea mining has taken place, there are relatively few direct studies of the environmental impacts of the industry. This is the current case with highly migratory species, which are generally not the focus of environmental impact assessments for nascent deep-sea mining prospects, nor the focus of research on the ecosystems that will be most directly impacted by deep-sea mining.

Direct Impacts

The process of deep-sea mining has several direct impacts on the seafloor, dependent on the topology of the mining site and the ore body.

Polymetallic sulphides. At hydrothermal vents, the direct impact to the immediate ecosystem will be catastrophic, resulting in complete defaunation and habitat destruction of the immediate vent environment (Van Dover, 2014). The geochemical processes that create these ore deposits provide chemical energy that supports novel ecosystems built on chemosynthetic primary production (Van Dover et al., 2018). Mining will result in the comprehensive extirpation of primary producers from the hydrothermal vent system. The ore cannot be isolated from the ecosystem (Collins et al., 2013). In the only study to date of the environmental impacts of mining a deep-sea hydrothermal vent, biodiversity collapsed following exploitation and had not recovered after three years (Washburn et al., 2023a).

Within biogeographic provinces, hydrothermal-vent communities are generally well-connected. Even in limited, controlled mining trials, downstream impacts will affect hydrothermal vents beyond the mining area (Thaler et al., 2017, 2014, 2011). At inactive hydrothermal vent systems, where the vents have shut down and the communities are no longer dominated by chemoautotrophic habitat builders, the successional communities appear dependent on remnant chemosynthetic activity. However, communities at inactive vents are generally very poorly studied and understood (Amon et al., 2022). Therefore, even at inactive vent sites, mining may result in comprehensive removal of endemic ecosystems (Erickson et al., 2009).

Cobalt-rich crusts. At cobalt-rich crusts, mining occurs on thick layers of crust coating the rocky tops and upper walls of seamounts. It results in the comprehensive removal of ore-bearing material as well as habitat for numerous species, including long-lived, slow growing sessile species like corals, from the encrusted rocky tops and upper walls of seamounts (Weaver and Billett, 2019). Seamounts tend to host high biomass ecosystems, providing habitat and supporting nursery grounds for commercially important fisheries (Morato et al., 2010). Though studies on the environmental impacts of mining cobalt-rich crusts are limited, baseline studies have shown that community structure on crusts differs from that of non-crust seamount regions and that recovery from mining disturbance will be slow (Schlacher et al., 2014). In the only study to date of the environmental impacts of mining a cobalt-rich crust, mobile epifauna were less abundant following disturbance (Washburn et al., 2023b).

Polymetallic nodules. Polymetallic-nodule extraction involves collecting nodules directly from the seafloor. The nodules themselves provide habitat for many species

20 Tonga SEABED MINERALS ACT 2014: https://faolex.fao.org/docs/pdf/ton143350.pdf

21 UNLEASHING AMERICA'S OFFSHORE CRITICAL MINERALS AND RESOURCES: https://www.whitehouse.gov/presidential-actions/2025/04/unleashing-americas-offshore-critical-minerals-and-resources/

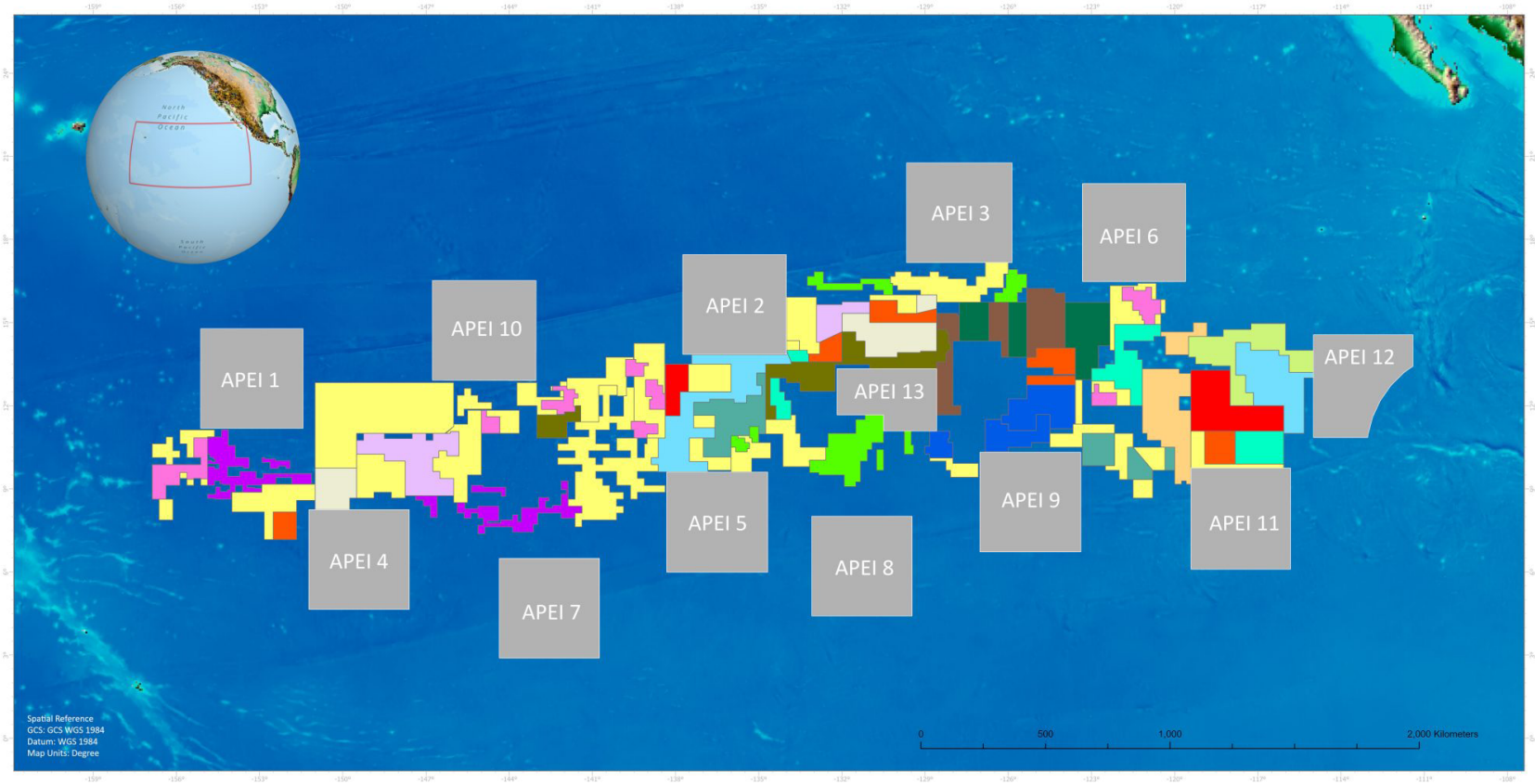


Figure 2: : Polymetallic Nodule exploration lease blocks and reserve areas in the Clarion-Clipperton Fracture Zone. Courtesy ISA.

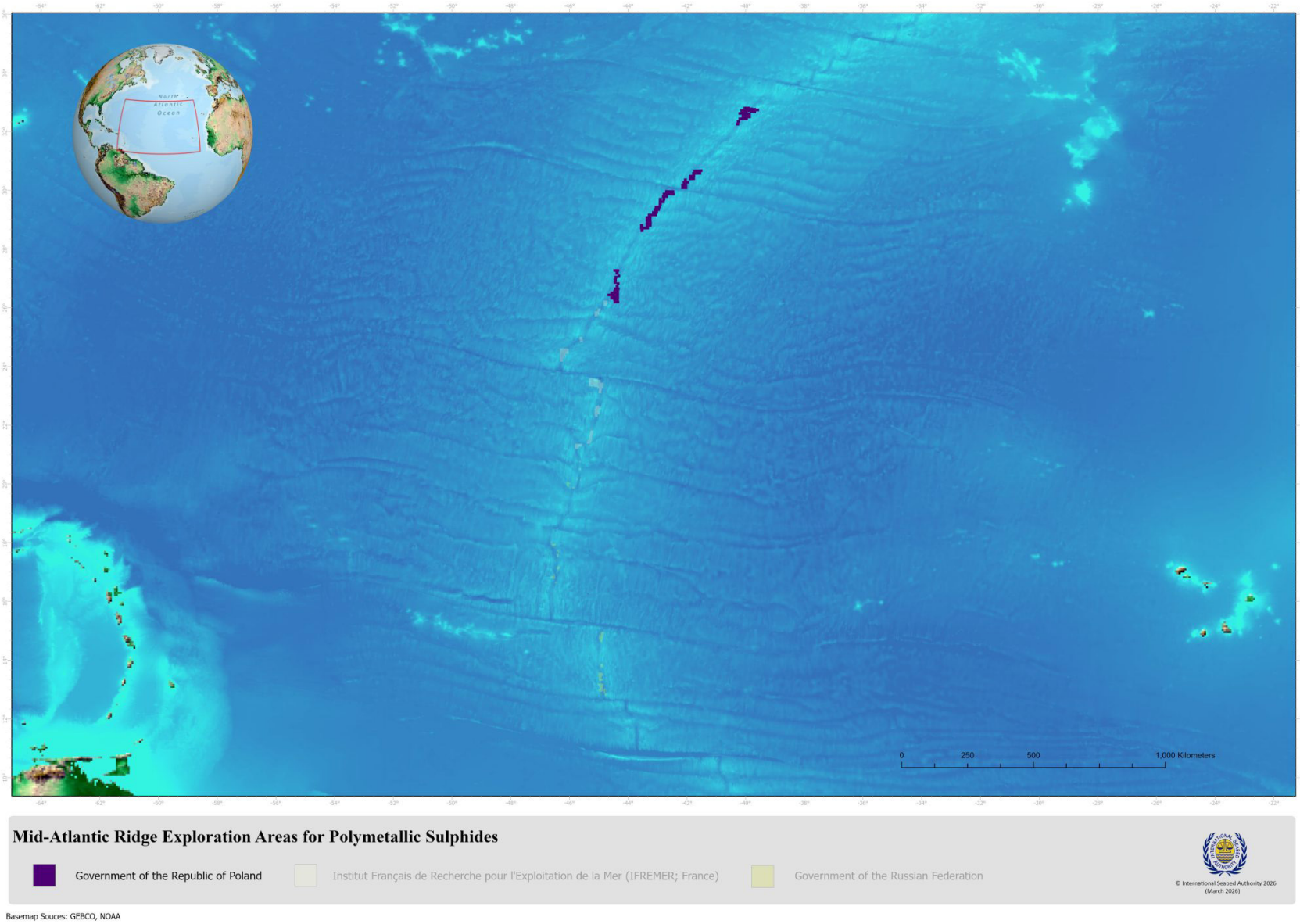


Figure 3: Seafloor Massive Sulphide exploration lease blocks on the Mid-Atlantic Ridge. Courtesy ISA.

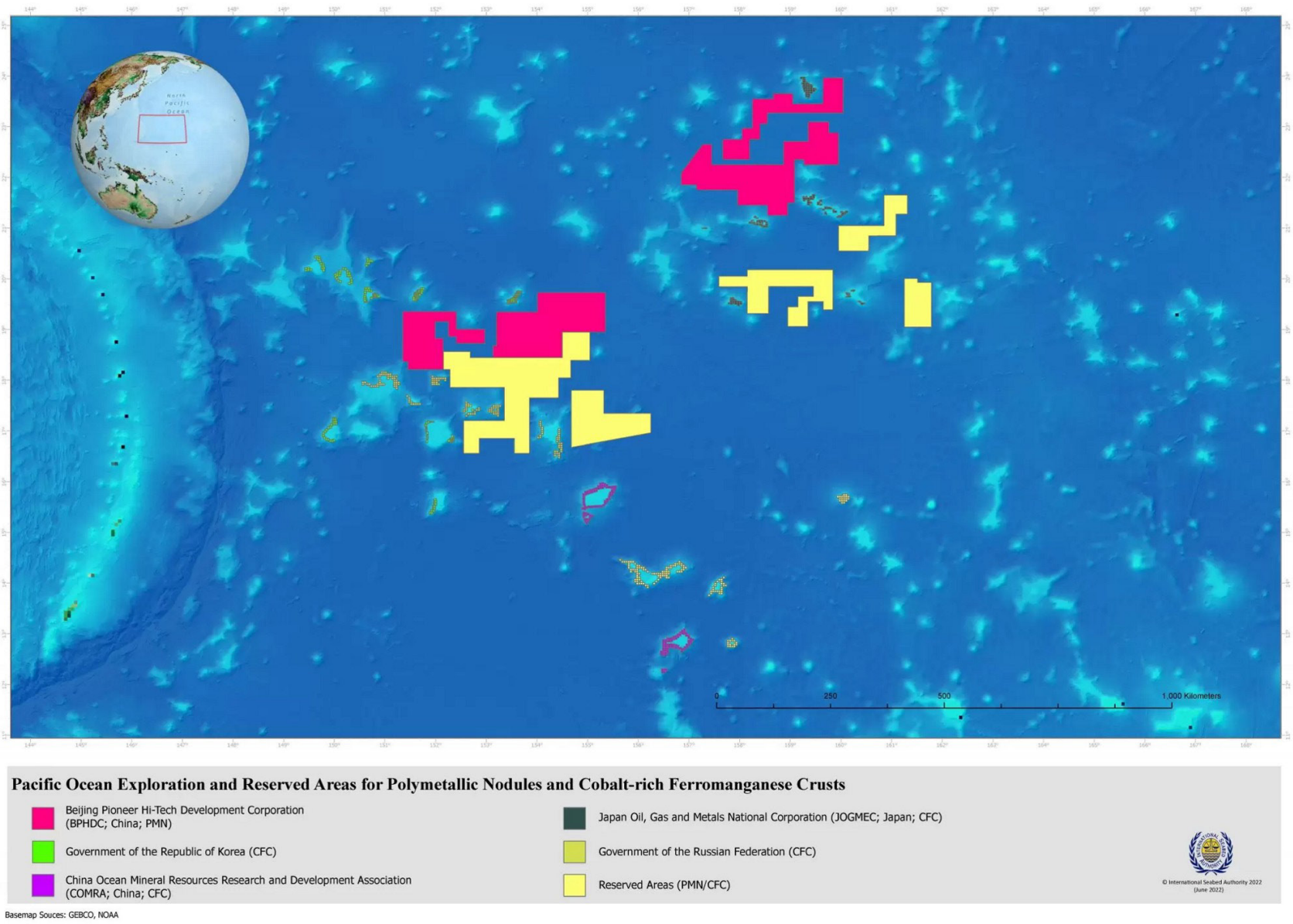


Figure 4: Polymetallic nodule and cobalt-rich crust exploration lease blocks and reserve areas in the Pacific Ocean. Courtesy ISA

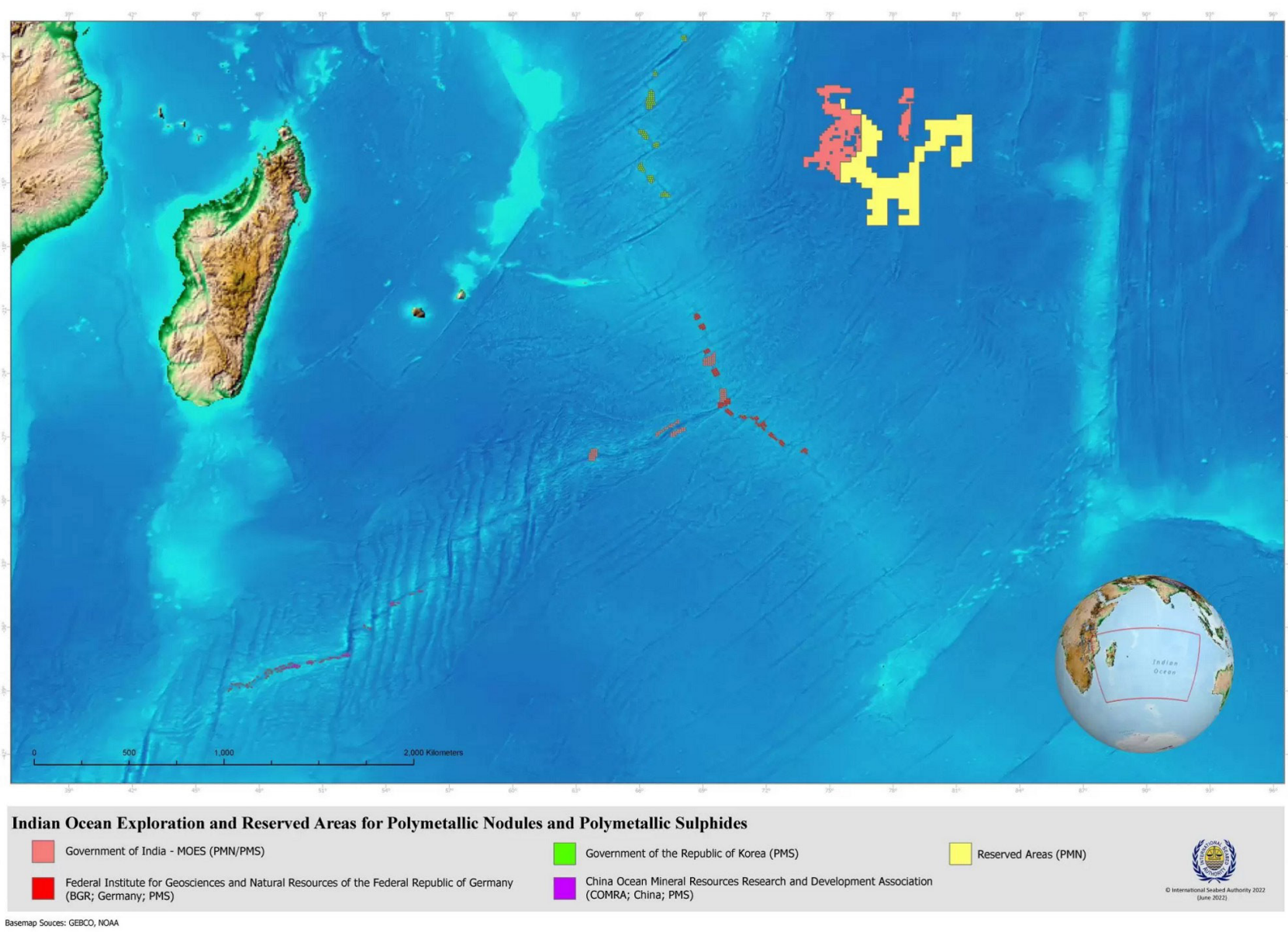


Figure 5: Polymetallic nodule and seafloor massive sulphide exploration lease blocks in the Indian Ocean. Courtesy ISA.

found exclusively within nodule fields, including sponges, corals, tube-building worms, barnacles and other species (Amon et al., 2016; De Smet et al., 2021). Nodule fields play a key role in abyssal plain communities, driving biodiversity, abundance and/or community composition, and may be critical for maintaining the integrity of deep food webs (Amon et al., 2016; Durden et al., 2021; Simon-Lledó et al., 2023, 2020; Stratmann et al., 2021; Uhlenkott et al., 2023; Vanreusel et al., 2016). Removal of nodules may also reshape the microbial ecosystem beneath the nodules (Wear et al., 2021).

Nodule-mining experiments were conducted in the 1970s and 1980s to assess the long-term impacts of deep-sea nodule mining, including at the DISturbance and re-COLonization experiment (DISCOL) site in the Peru Basin, which is among the best studied experimental mining sites (Thiel et al., 2001). Twenty-six years after the disturbance, there has been no sign of recovery of benthic filter feeders, and mobile scavengers have a quantitatively different community composition compared with the original community (Jones et al., 2017; Simon-Lledó et al., 2019). Microbial communities and ecosystem function may have also failed to recover (Molari et al., 2020; Volz et al., 2020; Vonnahme et al., 2020). Recent surveys have shown that biological impacts of polymetallic nodule mining persist for at least 44 years, though some mobile species have begun to re-establish (Jones et al., 2025). The direct impacts to the ecosystem of the immediate mining site will likely persist for at least several decades beyond the lifetime of the mine and may never recover to its pre-mining condition, given many of the fauna live directly on the nodules, which take millions of years to form.

Plumes

The production and spread of sediment plumes during the mining process is among the most variable of the potential impacts from deep-sea mining. Plumes evolve over space and time, represented in plume modelling by three distinct phases: a discharge phase, in which sediment is mobilized into the water column through contact with a collection vehicle or through midwater discharge during processing; a buoyancy-driven phase, where the primary force causing the sediment plume to propagate is its own buoyancy rather than momentum derived from the discharge phase; and a passive-transport phase, where plume propagation is driven by external factors such as currents (Muñoz-Royo et al., 2022). The extent – and thus environmental impact – of sediment plumes depends on the mining technology used in collecting and processing the ore (Peacock and Ouillon, 2023), the characteristics of the underlying sediment (Gillard et al., 2019), and the current regime and biodiversity present in these specific areas.

Picture 3. Kitefin shark spotted on the Eratosthenes Seamount. © Ocean Exploration Trust/NOAA

Collection plume. All forms of deep-sea mining generate a sediment plume at the seabed where the mining tool mobilizes sediment. This sediment plume could extend several kilometres across the deep seafloor (Gillard et al., 2019). Previously, the spread was thought to be up to 100 kilometres, but recent studies suggest that the extent of the plume may be much more limited, with the majority of sediment deposited within a few metres of the disturbance site and with lower concentrations of sediment in buoyant and passive-transport phases (Peacock and Ouillon, 2023). A recent independent assessment of an experimental nodule collector observed plumes dispersing up to at least 4.5 kilometres (the limit of the monitoring area), with suspended particle concentrations four times greater than background concentrations observed 50 metres from mining tracks, and approximately 3 centimetres of redeposited sediment adjacent to the mining tracks (Gazis et al., 2025).

All collection activities on the seabed can contribute to the discharge phase. While some collector designs may mobilize the top 5 to 15 cm of sediment (Peacock and Ouillon, 2023), others are being designed to operate with a presumptively less aggressive removal process.[22] The duration and propagation of the discharge phase plume will be highly dependent on the specific design and operation of the collection vehicle. During the buoyancy-driven phase, the plume may propagate beyond the immediate mining area, with heavy sedimentation occurring within 100 metres from the nodule collector (Burns, 1980). Observations of an experimental tracked mining vehicle in the Clarion-Clipperton Zone documented a plume that rose 3 metres above the seafloor and propagated for more than 100 metres beyond the immediate mining site (Muñoz-Royo et al., 2022). Between 2% and 8% of the mobilized sediment was detected more than 2 metres above the seafloor and did not settle out over several hours of observation. As the ultimate evolution of the plume can be mediated by environmental conditions, such as site-specific tidal influence, benthic currents and seafloor topography, as well as the specific design of the nodule collector, models predicting the total extent of the broadly dispersed, dilute passive-transport phase of the collection plume may be off by orders of magnitude. Precise prediction of plume propagation depends on accurate in-situ observations using operation-specific measurement of plume evolution (Peacock and Ouillon, 2023).

Collection plumes can smother the surrounding ecosystem, resulting in loss of marine habitat and biodiversity (Miller et al., 2018). Ore from deep-sea deposits may be enriched in heavy metals such as lead and arsenic, which can be mobilized into the ecosystem during mining (Hauton et al., 2017; Price et al., 2016). One study indicated that deep-sea marine mammals interact with the seafloor in the area around the Clarion-Clipperton Zone and that plume generation may disrupt feeding patterns (Marsh et al., 2018). Recent studies detected minimal residual effects from the sedimentation plume 44 years after a small-scale test nodule mine (Jones et al., 2025), but at the DISCOL site 26 years post-disturbance, megafauna and fish communities still showed impacts in plume-affected seafloor (Drazen et al., 2021; Simon-Lledó et al., 2019).

Return plume. Nodules recovered to the surface carry with them a fraction of benthic sediment. Depending on the method of extraction, this return plume can consist of ore-enriched sediments (including both particulate and dissolved metals), as well as water of differing temperatures and chemistries, produced when recovered ore is dewatered (Spearman et al., 2020). In the majority of proposed mining scenarios, this plume occurs in the midwater, though proposals to discharge the return plume closer to the seafloor have also been presented. As yet, there are no regulations to mandate the depth of the return plume. Midwater plumes are dominated by the passive-transport phase, where relatively low-concentration sediment plumes can persist for weeks – and sometimes up to more than four months – before finally settling out on the seafloor, allowing these plumes to disperse over hundreds or even thousands of kilometres (Peacock and Ouillon, 2023). Midwater plumes could potentially release chemical signatures that disrupt the migration of animals, especially those that participate in diel vertical migration or highly migratory species such as marine mammals (Drazen et al., 2019). It is also possible that discharged metals could enter midwater food webs and then bioaccumulate in higher trophic levels, including migratory and commercially important oceanic species (Amon et al., 2023).

The epipelagic and mesopelagic, in particular, has received relatively little consideration compared to the deep benthos where mining occurs (Drazen et al., 2020). Dewatering plumes, if released in the photic zone, may disrupt the nutrient flow in otherwise nutrient-limited waters, triggering algal blooms that could ultimately starve a region and smother seafloor communities once the algae begin to die off. Dewatering plumes will discharge large volumes of inorganic mud and ore particles into midwaters (~50,000m3 d-1; Drazen et al., 2020) that could dilute the organic detrital particles that deep-midwater filter feeders rely upon. This disruption to midwater food webs could affect highly migratory species such as tunas and CMS-listed species such as pelagic sharks. In one study, deep-sea corals exposed to suspended particles from polymetallic sulphides resulted

[22] Collingwood team creating friendlier robot for deep sea mining': https://www.collingwoodtoday.ca/local-news/collingwood-team-creating-friendlier-robot-for-deep-sea-mining-10773843

in tissue loss, necrosis, and the bioaccumulation of copper in coral specimens (Carreiro-Silva et al., 2022). A recent investigation into the potential effects of dewatering plumes on a deep-pelagic jellyfish indicated that deep-sea mining would negatively impact biodiversity and ecosystem function in the midwater zone (Stenvers et al., 2023).

Surface plume. Surface plumes can be produced by the dewatering process but will more likely be the result of accidental or emergency discharge. These discharges can alter the neuston directly surrounding the mining vessel (Helm, 2021) and interfere with migration and feeding behaviour of pelagic species, including marine mammals and migratory seabirds, as well as the pelagic communities they are dependent on. As no current deep-sea mining contractor proposes releasing surface plumes as part of their operations, studies on the promulgation of deep-sea mining-derived surface plumes are limited. Similar studies on the impact of plumes produced during dredging activities show that increased turbidity results in decreases to feeding and respiration rates for affected organisms (Todd et al., 2015). Mining contractors recognize that intentional surface discharge of nodule waste is "too environmentally challenging to be viable" (Peacock and Ouillon, 2023). At least one case of accidental surface plume discharge has already been reported from a deep-sea mining vessel conducting experimental trials in the Clarion-Clipperton Zone;[23] the unintentional discharge covered an area significant enough to be tracked from space (Yin et al., 2024).

Noise

With the exception of the hydrothermal vents associated with polymetallic sulphides, the soundscape of the deep sea is relatively quiet and poorly studied (Chen et al., 2021). One nodule field soundscape within Japan's EEZ was observed to be quieter even than Challenger Deep in the Mariana Trench (Chen et al., 2021). Deep-sea mining will introduce multiple new sources of marine noise pollution into regions that are historically lightly trafficked and exposed to limited anthropogenic noise. Mining operations involving robotic vehicles are expected to operate around the clock, with ore pumped continuously from the seafloor to the surface via a riser and lift system. A surface vessel, on site for months at a time, also contributes to altering the acoustic environment. Prospecting for new ore deposits and assessing the structural integrity of a mining site may involve the use of seafloor-penetrating SONAR. Noise from deep-sea mining operations can span vast areas, with acute impacts focused in the area immediately around the mining site and surface vessel (Williams et al., 2022). The cumulative impacts of chronic noise exposure from mining systems will likely have far greater impact than the short-term, acute sound exposure most often assessed in noise exposure studies (Williams et al., 2025).

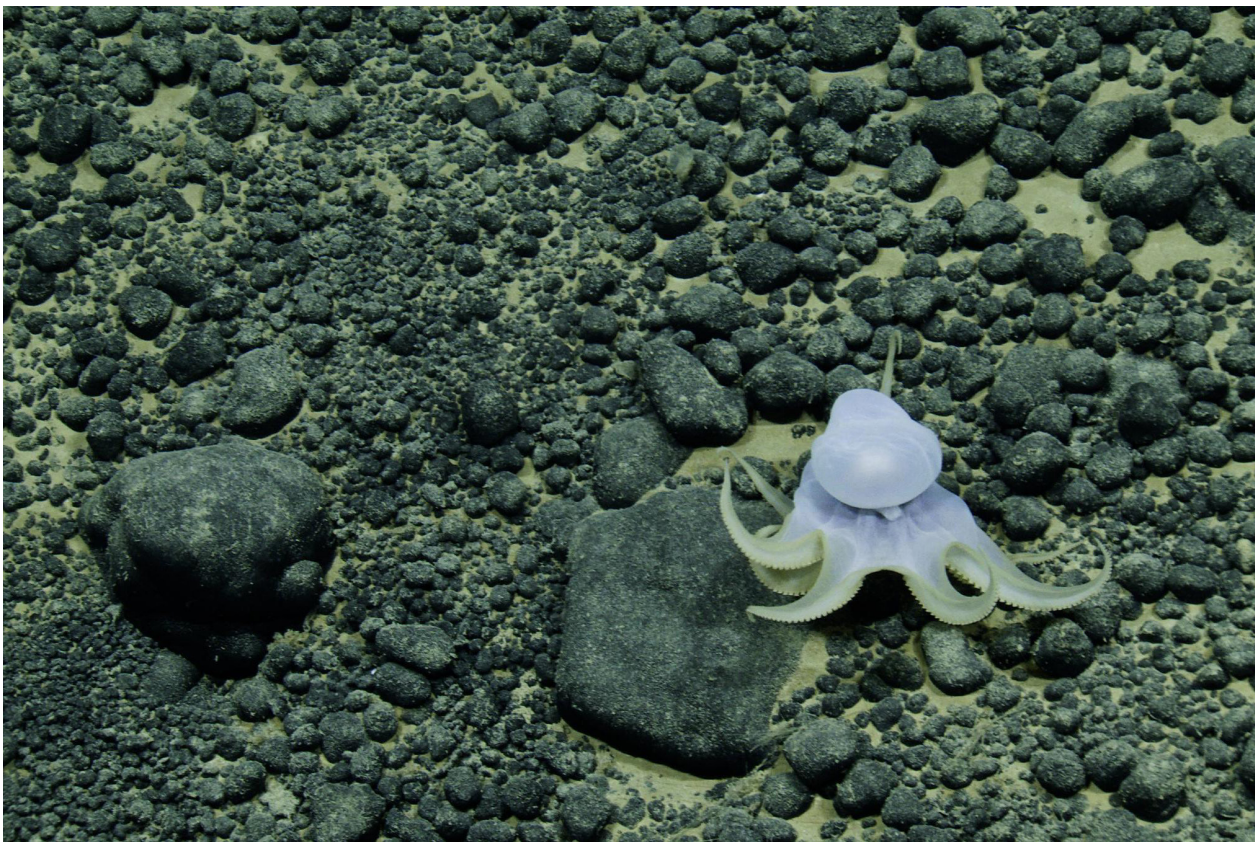
Habitat-specific soundscapes can serve as cue for settlement, and significant alterations to the deep soundscape could mask the acoustic signals that larvae use to locate appropriate habitats (Chen et al., 2021). The noise generated by a commercial nodule operation could produce a cylinder of sound of up to a 6 km radius, which exceeds standard thresholds for impacting the behaviour of marine mammals (Southall et al., 2019; Williams et al., 2022). Even relatively short-duration scientific research cruises using submersible assets have been shown to significantly alter the immediate soundscape (Chen et al., 2021).

For marine mammals, sea turtles and other migratory species, anthropogenic noise can cause behavioural changes, including interrupting feeding behaviours, altering vocalizations and triggering flight response from high-noise areas. Behavioural changes associated with anthropogenic noise are often unpredictable and not necessarily correlated with the volume of the noise source, but rather a multitude of factors (Williams et al., 2025). In the most extreme cases, high-intensity sound can lead to direct damage to ear structures, which can be lethal (Gomez et al., 2016). At least one study suggests that deep-diving beaked whales may interact with the seafloor in the Clarion-Clipperton Zone (Marsh et al., 2018). Many deep-sea mining contract areas are not only located in areas where cetaceans are active, but in regions that are otherwise rarely disturbed by human activities. The noise produced by mining operations are known to overlap with the frequency at which many cetaceans communicate, which may lead to permanent alteration in the behaviour of populations still in recovery from two centuries of commercial whaling (Thompson et al., 2023). Furthermore, in a systematic review of the impacts of deep-sea mining-derived noise in the Clarion-Clipperton Zone, only 35% of marine taxa known to inhabit the area were assessed for noise sensitivities, but noise sensitivity was pervasive across all represented vertebrates, showing little is known about this potential impact (Amon et al., 2022; Williams et al., 2025).

Indirect Impacts

For migratory species, especially those that primarily interact with the surface layers of the ocean, and deep-diving species that forage in areas that overlap with mining sites, including tuna, swordfish and marine mammals, the indirect impacts of deep-sea mining may prove to be more significant. This includes changes in the behaviour of prey species induced by deep-sea mining, increased exposure to mobilized toxins through bioaccumulation, and alteration to biogeochemical processes, which are not yet fully understood.

23 Leaked video footage of ocean pollution shines light on deep-sea mining': https://www.theguardian.com/environment/2023/feb/06/leaked-video-footage-of-ocean-pollution-shines-light-on-deep-sea-mining



Picture 4. An unidentified Casper octopus crawls across a polymetallic nodule field in the Cook Islands. © Ocean Exploration Trust/NOAA

Commercially Important Fisheries

Bigeye, skipjack and yellowfin tuna populations are present within the CCZ, and fall under the aegis of two regional fisheries management organizations in that part of the ocean (van der Grient and Drazen, 2021). The populations fished in the CCZ represent some of the most valuable commercial fisheries in the world. There is significant spatial overlap between deep-sea mining contract areas and fishing grounds (van der Grient and Drazen, 2021), which will likely lead to direct conflict between these two industrial activities, especially as climate change drives increasing overlaps between the two activities (Amon et al., 2023). Metal-enriched discharge plumes may also cause heavy metals to enter the food web, resulting in bioaccumulation within apex predators and spoiling the value of fisheries, as happened with the bioaccumulation of mercury in swordfish (Amon et al., 2023). Many commercially important fish species are also prey for animals covered under CMS. Changes in prey dynamics can result in alternation of foraging and predation behaviour, as well as other behavioural changes. The bioaccumulation of heavy metals can result in significant adverse health effects for high-trophic-level predators (Ray and Vashishth, 2024).

Radiation from Polymetallic Nodules

Polymetallic nodules were recently identified as naturally occurring radioactive materials, enriched in uranium-series radioisotopes that emit alpha radiation during decay. These include thorium-230, radium-226 and protactinium-231, as well as radon-222. While alpha particles have a travel distance limited to a few centimetres and do not generally penetrate the skin, their high energy content makes them particularly harmful if they enter the body through ingestion or inhalation. In one study, thorium-230 emissions from polymetallic nodules was 36 times the US EPA Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings; radium-226 was 47 times the limit (Volz et al., 2023). This poses a particular risk to those actively engaged in the mining and processing of polymetallic nodules and complicates downstream waste disposal.

The ISA issued a statement regarding potential radioactive content in polymetallic nodules indicating that "there are no plans for ISA to discuss safety regulations for workers around Deep Sea Mining".[24] As nodule processing will likely occur on land, based on current mining technology, it remains unclear if any potential radiation exposure from the processing of polymetallic nodules would be linked to adverse impacts to highly migratory species.

[24] ISA Fact-check 2023/2 – Radioactivity of nodules: https://www.isa.org.jm/isa-fact-check-2023-2/

Dark Oxygen

A recent study describes the presence of 'dark oxygen' – oxygen produced by an as yet undescribed biogeochemical process mediated by polymetallic nodules on the seafloor (Sweetman et al., 2024). The production of dark oxygen resulted in a more than threefold increase in background oxygen concentration in in-situ benthic chamber experiments. If validated by further study, this would be a significant discovery that could fundamentally reshape our understanding of the seafloor ecosystem. However, the preliminary study has been questioned and the underlying process that produces dark oxygen remains elusive (Voosen, 2024). Should the generation method be elucidated, dark oxygen production could play a critical role in material cycling and carbon sequestration in the deep sea, and offer a potential new source of renewable energy (Shangguan, 2025). The production of dark oxygen would also be of substantive concern for the development of deep-sea mining and would necessitate significant re-evaluation of the known and unknown impacts of the industry (Siddiqui, 2025).

The biological relevance of dark oxygen to the broader ocean ecosystem, including CMS species and their prey, has not yet been characterized. Verifying the existence of dark oxygen and characterizing the biogeochemical process that leads to its production, remains a tantalizing subject for future research.

Underwater Cultural Heritage

The vast majority of potential deep-sea mining is proposed in areas beyond national jurisdiction. Relatively little consideration has been given to the social and cultural impacts of deep-sea mining. Lack of stakeholder engagement with the peoples that may be most immediately affected by deep-sea mining is a frequent point of contention among ISA delegations (Jaeckel et al., 2023).

Deep-sea mining comes in direct conflict with, in particular, the cultural heritage of Pacific Islanders.[25] Deep-sea mining leases fall within both the Micronesian and Polynesian Voyaging Triangles – areas where traditional navigators have established and maintained connections between remote islands over millennia. Furthermore, many culturally significant migratory species occur in proposed mining areas in the Pacific (Tilot et al., 2021).

Deep-sea hydrothermal vents have significant cultural and scientific value. The first deep-sea marine protected areas were established around historically important hydrothermal vent fields within the Marine Park of the Azores and the Endeavour Hydrothermal Vents Marine Protected Area in Canada (Menini and Van Dover, 2019). The Middle Passage, a region of the Mid-Atlantic, encompasses the historic route through which millions of enslaved people were transported from West Africa to the Americas and the Caribbean, and serves as a maritime graveyard for up to 2 million people (Turner et al., 2020). Several ISA-issued deep-sea mining leases fall within the historic seaways of the Middle Passage. At least one campaign to declare the seafloor of the Middle Passage as a maritime cemetery is underway.[26]

Other Impacts

Other possible indirect impacts include the greater likelihood of ship strikes due to increased vessel traffic within relatively low-traffic areas, the potential for stationary mining vessels to act as fish aggregating devices or seabird attractants, and knock-on impacts resulting from avoidance behaviour in CMS-listed species and their prey.

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25 Connecting Conservation and Culture in Oceania: https://www.angelovillagomez.com/2022/09/connecting-conservation-and-culture-in.html

26 Group urges Atlantic seafloor be labeled a memorial to slave trading: https://today.duke.edu/2020/11/group-urges-atlantic-seafloor-be-labeled-memorial-slave-trading

Mammalia (Marine Mammals)

Of the 86 CMS-listed marine mammals, at least 41 are known to occur within either an ISA-issued contract area or proposed mining area within a nation's EEZ. These include at least eight species of deep-diving beaked whales, whose feeding habitat may directly overlap with mining sites in the CCZ, as well as other highly migratory species whose migration routes intersect with proposed contract areas in the Atlantic, Pacific and Indian Oceans, and some seal species whose ranges overlap with proposed mining exploration zones within the EEZ of Norway. The CCZ is considered an Area of Interest by the IUCN Marine Mammal Protected Area Task Force, while the migratory corridor through the North Atlantic overlaps with polymetallic sulphide contract areas and is considered an Important Marine Mammal Area.[27]

Beaked whales may interact with and be affected by deep-sea mining in a variety of ways, particularly disruption of feeding behaviours in deep-diving species, as well as changes in prey availability, soundscapes and migration behaviours. Beaked whales, which comprise up to 25% of all cetaceans yet are among the least studied cetacean species, may be particularly impacted by deep-sea mining. These species feed on demersal fish, including rattails common to the deep abyssal plains (Ohizumi et al., 2003). Cuvier's beaked whale (*Ziphius cavirostris*) is known to dive to almost 3,000 metres (Schorr et al., 2014) and marks found on the seafloor in the CCZ suggest that beaked whales interact directly with the seafloor within ISA contract areas (Marsh et al., 2018). Cuvier's beaked whale and Blainville's beaked whale (*Mesoplodon densirostris*; Rosso et al., 2021) have circumglobal distribution. Sowerby's beaked whale (*Mesoplodon bidens*), True's beaked whale (*Mesoplodon mirus*) and Gervais' beaked whale (*Mesoplodon europaeus*) are found in the Atlantic and may cross mining contract areas on the Mid-Atlantic Ridge (Macleod, 2000). Ginkgo-toothed beaked whale (*Mesoplodon ginkgodens*; Rosso et al., 2021) and Baird's beaked whale (*Berardius bairdii*; Ohizumi et al., 2003) have, so far, only been documented in the Pacific. Other marine mammals, like the bottlenosed whale (*Hyperoodon ampullatus*), are also known deep-divers (Hooker and Baird, 1999).

Sperm whales (*Physeter macrocephalus*; Alexander et al., 2016) are another deep-diving species, typically feeding at depth. They are the only marine mammal species that

Picture 5. Endeavor Hydrothermal Vent complex. © Ocean Exploration Trust/Neptune Canada

27 IMMA e-Atlas - https://www.marinemammalhabitat.org/imma-eatlas/

has been positively identified to the species level within the publicly available environmental reports provided through the ISA DeepData portal. Sperm whale clicks were detected at a deep-water acoustic array deployed by TMC in the CCZ, providing evidence that these animals are active and feeding within mining exploration contract areas.

The largest baleen whales may interact with and be affected by deep-sea mining in a variety of ways, including changes in prey availability, soundscapes and migration behaviours, disruption of feeding behaviours, and, more directly, potential increases in ship strikes. Almost all large whales overlap with proposed deep-sea mining sites during their lifetime, including common minke whales (*Balaenoptera acutorostrata;* Kasamatsu et al., 1995; van Pijlen et al., 1995), sei whales (*Balaenoptera borealis*; Ishii et al., 2017), Bryde's whales (*Balaenoptera edeni*; Heimlich et al., 2005; Rosel et al., 2021), and fin whales (*Balaenoptera physalus*; Edwards et al., 2015). Many of these species feed at the surface in high latitudes or temperate waters and migrate through known deep-sea mining sites to breeding and foraging grounds.

The blue whale (*Balaenoptera musculus*; Branch et al., 2007) is globally distributed but has a unique Indian Ocean subpopulation (Andersen et al., 2012), which engages in midwater feeding (de Vos et al., 2018, 2016) and whose range may overlap with mining sites on the Indian Ocean Triple-Junction as well as proposed test sites within India's EEZ. The humpback whale (*Megaptera novaeangliae*) participates in one of the longest seasonal migrations of any mammal (Jackson et al., 2014) and may overlap with almost all proposed mining sites. Other large whale species may not have ranges that directly overlap, or there may not be enough well-documented evidence to estimate their range, as in the case of Omura's whale (*Balaenoptera omurai;* Cerchio et al., 2019). Some whales whose range does not currently overlap with proposed mining sites, may do so in the future due to climate-induced range expansion, as in the case of the North Atlantic right whale (*Eubalaena glacialis*; Hunt et al., 2015).

Though often found in resident pods, many dolphin species have a global distribution, and even dolphins that are generally coastal may migrate across potential deep-sea mining sites. The bottlenose dolphin (*Tursiops truncatus*), for example, is globally distributed (Tezanos-Pinto et al., 2009), and while it has a high degree of residency (Rosel et al., 2009), there is evidence of long-distance dispersal (Klatsky et al., 2007) among offshore ecotypes. Similar phenomena can be found, to a greater or lesser extent, in Fraser's dolphin (*Lagenodelphis hosei*; Chen et al., 2020; Gomes-Pereira et al., 2013), rough-toothed dolphin (*Steno bredanensis*; da Silva et al., 2015), common dolphin (*Delphinus delphis*; Barceló et al., 2022), Risso's dolphin (*Grampus griseus*; Jefferson et al., 2014), and the Pacific Dall's porpoise (*Phocoenoides dalli;* Escorza-Treviño and Dizon, 2000), which shows evidence of male-biased dispersal.

Killer whale (*Orcinus orca*; Blanc and Martínez-Rincón, 2023) are similarly globally distributed and, along with false killer whales (*Pseudorca crassidens*), may be particularly sensitive to sound (Madsen et al., 2004).

Pelagic dolphins can be found in all major oceans, and many species have been documented feeding on mesopelagic fish in the midwaters where dewatering plumes may be released. The pantropical spotted dolphin (*Stenella attenuate*; Díaz-Torres et al., 2022) and striped dolphin (*Stenella coeruleoalba*; Ringelstein et al., 2006) have been documented feeding on lanternfish from the midwater. Spinner dolphin (*Stenella longirostris*; Leslie and Morin, 2018) are globally distributed throughout the tropics, as are Clymene dolphin (*Stenella clymene* Weir et al., 2014) and Atlantic spotted dolphin (*Stenella frontalis;* Adams and Rosel, 2006). The circumglobal melon-headed whale (*Peponocephala electra*; Martien et al., 2017) is behaviourally similar to pelagic dolphins.

Though most migratory marine mammals whose ranges overlap with potential deep-sea mining sites have circumglobal or circumtropical distributions, a few have more restricted ranges. The Atlantic white-sided dolphin (*Lagenorhynchus acutus*; Banguera-Hinestroza et al., 2014) and the white-beaked dolphin (*Lagenorhynchus albirostris;* Canning et al., 2008) occur in the northern Atlantic and may only overlap with mining exploration contract areas on the Mid-Atlantic Ridge. The two pilot whale species, short-finned pilot whale (*Globicephala macrorhynchus*) and long-finned pilot whale (*Globicephala melas*) have global, but non-overlapping ranges, with long-finned pilot whales co-occurring with potential deep-sea mining sites on the Mid-Atlantic Ridge, while short-finned pilot whales have a broader multi-ocean range overlapping with multiple potential mining sites (Oremus et al., 2009).

Norway's recent plans to develop mining leases at polymetallic sulphides within Norwegian waters[28] may place some coastal marine mammal species at risk. The ranges of harbour porpoises (*Phocoena phocoena*; Mikkelsen et al., 2016), grey seals (*Halichoerus grypus;* Øigård et al., 2012), harbour seals (*Phoca vitulina*; Bjørge et al., 2010), Atlantic white-sided dolphin (*Lagenorhynchus acutus*; Banguera-Hinestroza et al., 2014) and white-beaked dolphin (*Lagenorhynchus albirostris*; Canning et al., 2008) overlap with a proposed deep-sea mining contract area in Norway (though permits for the contract area have been temporarily suspended).[29]

28 Norway suspends controversial deep-sea mining plan: https://www.bbc.com/news/articles/c9wlj8l8kr7o

29 Deep-sea mining: Norway approves controversial practice: https://www.bbc.com/news/science-environment-67893808

Table 1: Marine mammal species listed under CMS with potential range overlaps with existing ISA or national mining leases

Scientific Name	Common Names	CMS Instruments and Appendices[30]	IUCN Red List Status[31]	Potential Range Overlap
Balaenoptera acutorostrata subspp.	Common minke whale	PIC MOU	LC	Global
Balaenoptera borealis	Sei whale, coalfish whale, pollack whale, Rudolph's rorqual	CMS App. I & II, ACCOBAMS, ASCOBANS, PIC MOU	EN	Global
Balaenoptera edeni	Bryde's whale, tropical whale	CMS App. II, PIC MOU	LC	Global
Balaenoptera musculus	Blue whale	CMS App. I, PIC MOU	EN	Global
Balaenoptera physalus	Fin whale	ACCOBAMS, PIC MOU	VU	Global
Berardius bairdii	Baird's beaked whale	CMS App. II, PIC MOU	LC	Pacific
Delphinus delphis	Common dolphin	CMS App. I (Mediterranean population) & II (North and Baltic Sea, Mediterranean, Black Sea and eastern tropical Pacific populations), ACCOBAMS, ASCOBANS, PIC MOU, WAAM MOU	LC	Mid-Atlantic Ridge (MAR) / Pacific
Eubalaena glacialis	North Atlantic right whale, Biscayan right whale	CMS App. I (North Atlantic), ACCOBAMS, ASCOBANS	CR	MAR
Globicephala macrorhynchus	Short-finned pilot whale	PIC MOU, ASCOBANS, WAAM MOU	LC	Global
Globicephala melas	Long-finned pilot whale	CMS App. II (North and Baltic Sea populations), ACCOBAMS, ASCOBANS, PIC MOU, WAAM MOU	LC	MAR
Grampus griseus	Risso's dolphin	CMS App. II (North Sea, Baltic Sea, and Mediterranean populations), ACCOBAMS, ASCOBANS, PIC MOU, WAAM MOU	LC	Pacific/Indian
Halichoerus grypus	Grey seal	CMS App. II (Baltic Sea populations)	LC	MAR
Hyperoodon ampullatus	Northern bottlenose whale, bottle-nosed whale	CMS App. II, ASCOBANS, WAAM MOU	NT	MAR
Indopacetus pacificus	Tropical bottlenose whale	PIC MOU	LC	Indian
Kogia breviceps	Pygmy sperm whale	ASCOBANS, PIC MOU, WAAM MOU	LC	Global
Kogia sima	Dwarf sperm whale	ACCOBAMS, ASCOBANS, PIC MOU, WAAM MOU	LC	Global
Lagenodelphis hosei	Fraser's dolphin	CMS App. II (Southeast Asian populations), PIC MOU, WAAM MOU	LC	Global

30 See Annex 1 & 2

31 See Annex 3

Scientific Name	Common Names	CMS Instruments and Appendices[30]	IUCN Red List Status[31]	Potential Range Overlap
Lagenorhynchus acutus	Atlantic white-sided dolphin	CMS App. II (North and Baltic Sea populations), ASCOBANS	LC	MAR
Lagenorhynchus albirostris	White-beaked dolphin	CMS App. II (North and Baltic Sea populations), ASCOBANS	LC	MAR
Megaptera novaeangliae	Humpback whale	CMS App. I, ACCOBAMS, PIC MOU	LC	Global
Mesoplodon bidens	Sowerby's beaked whale	ASCOBANS, WAAM MOU	LC	MAR
Mesoplodon densirostris	Blainville's beaked whale	ACCOBAMS, ASCOBANS, PIC MOU, WAAM MOU	LC	Global
Mesoplodon europaeus	Gervais' beaked whale	ASCOBANS, WAAM MOU	LC	MAR
Mesoplodon ginkgodens	Ginkgo-toothed beaked whale	PIC MOU	DD	Pacific
Mesoplodon mirus	True's beaked whale	ASCOBANS, PIC MOU, WAAM MOU	LC	MAR
Monachus monachus	Mediterranean Monk Seal	CMS App. I & II, Monk Seal MOU	VU	MAR
Orcinus orca	Killer whale, orca	CMS App. II, ACCOBAMS, ASCOBANS, PIC MOU, WAAM MOU	DD	Global
Peponocephala electra	Melon-headed whale	PIC MOU, WAAM MOU	LC	Global
Phoca vitulina	Common seal, harbour seal	CMS App. II (Baltic and Wadden Sea populations)	LC	MAR
Phocoena phocoena	Common porpoise, harbour porpoise	CMS App. I (Baltic Proper population) & II (North and Baltic Sea, western North Atlantic, Black Sea and North West African populations), ACCOBAMS, ASCOBANS, WAAM MOU	LC	MAR
Phocoenoides dalli	Dall's porpoise	CMS App. II	LC	Pacific
Physeter macrocephalus	Sperm whale	CMS App. I & II, ACCOBAMS, PIC MOU	VU	Global
Pseudorca crassidens	False killer whale	ACCOBAMS, ASCOBANS, PIC MOU, WAAM MOU	NR	Global
Stenella attenuata	Pantropical spotted dolphin, bridled dolphin	CMS App. II (eastern tropical Pacific population, Southeast Asian populations), PIC MOU, WAAM MOU	LC	Global
Stenella clymene	Clymene dolphin	CMS App. II (West African population), WAAM	LC	MAR
Stenella coeruleoalba	Striped Dolphin, Blue-White Dolphin	CMS App. II (eastern tropical Pacific population, Mediterranean population), ACCOBAMS, ASCOBANS, PIC MOU, WAAM MOU	LC	Global

Scientific Name	Common Names	CMS Instruments and Appendices[30]	IUCN Red List Status[31]	Potential Range Overlap
Stenella frontalis	Atlantic spotted dolphin	WAAM MOU	LC	MAR
Stenella longirostris	Spinner dolphin	CMS App. II (eastern tropical Pacific populations, Southeast Asian populations) PIC MOU, WAAM MOU	LC	Global
Steno bredanensis	Rough-toothed dolphin	ACCOBAMS, ASCOBANS, PIC MOU, WAAM MOU	LC	Global
Tursiops truncatus	Bottlenose dolphin	CMS App. II (North Sea, Baltic Sea, Mediterranean and Black Sea populations), ACCOBAMS, ASCOBANS, WAAM MOU	LC	Global
Ziphius cavirostris	Cuvier's beaked whale	CMS App. I (Mediterranean subpopulation), ACCOBAMS, ASCOBANS, PIC MOU, WAAM MOU	LC	Global

For many little-known species, the range data – which, in some cases, points to circumglobal or ocean-spanning ranges – is often derived from stranding reports, rather than direct observations in the wild. Pygmy and dwarf sperm whale (*Kogia breviceps* and *Kogia sima*) distributions, for example, are derived largely from stranding data (Plön et al., 2023). The tropical bottlenosed whale (*Indopacetus pacificus*), whose known range is currently limited to the Indian Ocean, is known only from a few specimens (Dalebout et al., 2003).

Potential Impacts and Associated Knowledge Gaps

Ship Strikes. For many large marine mammals, ship strikes are a major cause of mortality (Redfern et al., 2020). Deep-sea mining operations, using tenders to deliver ore to onshore processing facilities, will increase the amount of ship traffic in areas that are generally outside of major shipping lanes, and increase the likelihood of ship strikes in the high seas. One study on blue whale populations indicates that an 11-fold increase in vessel activity could result in a 50% chance that blue whale populations would be depleted (Monnahan et al., 2015).

The impact of ship strikes on marine mammals and methods to reduce ship strikes, including changing routes and operating at low speeds, have been well studied (Nisi et al., 2024; Redfern et al., 2013; Ritter and Panigada, 2019). As this problem is not unique to deep-sea mining – nor does deep-sea mining create unique conditions for ship strikes – the conventional guidance for all vessel operators is applicable.

Fish Aggregation Devices. Stationary vessels in the open ocean may act as fish aggregation devices (FADs) (Røstad et al., 2006). Marine mammals and their prey may be attracted to mining vessels on station, creating an opportunity for increased observation of migratory marine mammals and potentially disrupting feeding patterns and other types of behaviour. Dolphins are known to aggregate around FADs and sei whales have been observed visiting FADs in the Indian Ocean (Brehmer et al., 2012).

Noise. The effect of anthropogenic noise on marine mammals has been well characterized over many decades, with a large body of literature assessing impacts (e.g. Hildebrand, 2009; Richardson et al., 2013; Simmonds et al., 2014; Tyack, 2008; Weilgart, 2007). Noise from both mining activity and from the dynamic positioning systems used by mining vessels could have adverse impacts on marine mammal behaviour. These operations are anticipated to run 24-hours a day over a variety of ocean depths throughout the course of months or years (Thompson et al., 2023). Noise generated by the machinery involved in deep-sea mining will likely have direct impacts on cetaceans (Thompson et al., 2023; Williams et al., 2025, 2022).

The introduction of noise into a relatively quiet acoustic environment can reduce the range, area and volume over which biologically important signals can be detected. Noise from deep-sea mining operations may also act as a chronic, habitat-level stressor, resulting in acoustic masking, by which unwanted sound hinders the ability of marine mammals to detect auditory signals (Clark et al., 2009; Erbe et al., 2016). Numerous prey species that occur within areas like the CCZ are known

to use sound for communication or navigation, and chronic ocean noise produced by a deep-sea mining operation could mask the ability of prey species to detect predator vocalizations or, vice versa, impacting the feeding behaviour of marine mammals that prey upon them (Williams et al., 2025). Marine mammals and their prey coevolved acoustic adaptations for hunting and avoidance in an 'acoustic arms race' (Tyack and Clark, 2000), and chronic ocean noise could alter this balance between predator and prey. The masking of acoustic signals can also affect the ability of marine mammals to find and select mates or detect acoustic cues used for navigation. Chronic ocean noise may also induce physiological stress in marine mammals, leading to adverse health effects or suppression of reproductive behaviours (Rolland et al., 2012; Wright et al., 2007).

Deep-sea mining poses emerging risks to deep-diving marine mammals, potentially triggering physiological stress responses similar to those associated with naval sonar. While the mechanisms differ, the chronic low-frequency noise generated by mining machinery may disrupt natural diving behaviour, displace animals from key foraging habitats, and increase the likelihood of rapid or abnormal ascents. These disruptions could elevate the risk of decompression sickness (DCS), particularly in sensitive species like beaked whales that regularly dive to extreme depths (Beatty and Rothschild, 2008). DCS – caused by the formation of nitrogen gas bubbles in tissues and blood – has been linked to several mass stranding and mortality events, notably in regions where military sonar was active (Velázquez-Wallraf et al., 2021). Necropsies from such events have revealed gas emboli, haemorrhages and lesions consistent with acute decompression pathology (Fernández et al., 2017). Although no strandings have yet been directly attributed to mining, the cumulative impacts of noise, habitat degradation and prey displacement in mining areas warrant precaution, especially given the similarities in risk pathways.

The impact of noise on marine mammals is one of the few potential impacts to migratory species for which deep-sea mining contractors have undertaken baseline environmental studies and provided raw data for evaluation. In 2019, deep and shallow hydrophone recordings were supplied from contract areas for The Metals Company within the Clarion-Clipperton Zone. Delphinid whistles, minke whale calls, and sperm whale clicks were recorded from the shallow array, while delphinid whistles were recorded from the deep array. These acoustic records are more numerous than the reported visual records, suggesting that marine mammals are more active in the region than visual observer data may indicate.

The noise produced by deep-sea mining operations has not been well characterized, and the primary knowledge gap is in understanding how deep-sea

Picture 6. Right whale with two series of propeller scars on his side © Florida Fish and Wildlife Conservation Commission, NOAA Research Permit # 594-1759

mining-derived noise will propagate throughout the target area and beyond.

While there is a growing body of literature for predicting population-level consequences of acute noise in cetaceans (Pirotta et al., 2018), efforts to understand the consequences of chronic ocean noise are preliminary. A large body of literature now exists on the impact of anthropogenic marine noise, leading to concern that chronic noise from deep-sea mining would also substantially affect cetaceans (Rose et al., 2024). Chronic exposure to continuous low-frequency noise and the degradation of the cetacean acoustic environment would have consequences to both individuals and populations, but we currently lack the analytical tools to estimate those costs. Case studies that try to quantify the consequences of masking or disturbance from chronic ocean noise are limited (Williams et al., 2025). Other industrial proxies can be used to approximate the noise-generating activities that may occur during deep-sea mining operations (Williams et al., 2022), but it is unknown how well these proxies align with deep-sea mining operations. Comparative studies generally demonstrate that the impact of noise on some cetacean species in shallow water can be used as appropriate proxies but not in all cases (Katona et al., 2023). While studies on source characteristics, propagation and sensitivity to these chronic noises are needed to assess the impact deep-sea mining will have on cetaceans, current best available science suggests that a precautionary approach to the production of chronic underwater noise is already warranted (Risch et al., 2021).

Plumes. The presence of midwater or surface plumes produced by mining activity may alter chemical signals that marine mammals use to navigate and detect prey. Increased suspended sediment concentrations can be a major stressor for marine animals, including both marine mammals and their prey, challenging their ability to see and communicate (van der Grient and Drazen, 2022). The release of metals and contaminants in the midwater plume may directly affect cetaceans, including through bioaccumulation. Relatively little is known about the impacts of midwater and benthic plumes on cetaceans. The effects of these impacts on higher-trophic-level cetacean species should not be overlooked

How sediment plumes behave when generated by deep-sea mining operations is still not well characterized (Haalboom et al., 2022). The impact of these plumes on cetaceans and on the ecosystems essential for their survival is even less well understood. Sediment plumes could affect food webs (Peacock and Ouillon, 2023; Thompson et al., 2023; van der Grient and Drazen, 2022). The impacts of releasing ocean carbon (Souster et al., 2024) or contaminants including toxic metals (Hauton et al., 2017) sequestered in the seabed are also a concern (Martins et al., 2023).

Entanglement. Though entanglement in fishing gear is a significant source of mortality and small remotely operated vehicles use tethers that may present an entanglement hazard (Thaler et al., 2019), the cables used by deep-sea mining operators – which are not only thicker and stiffer than lines used in commercial fishing, but are also continuously monitored – do not appear to pose the same risk.

Chondrichthyes (Cartilaginous Fishes)

Of the 47 cartilaginous fishes listed under the Convention, 18 have ranges that overlap with potential or proposed deep-sea mining sites. The majority of these species are circumglobal in distribution, reported or inferred to occur in all high-seas areas where deep-sea mining may take place. These include bigeye and common thresher sharks (*Alopias superciliosus* and *Alopias vulpinus*), silky shark (*Carcharhinus falciformis*), oceanic whitetip shark (*Carcharhinus longimanus*; Young and Carlson, 2020), great white shark (*Carcharodon carcharias*; Kock et al., 2022; Skomal et al., 2017; Weng et al., 2007), basking shark (*Cetorhinus maximus*), shortfin and longfin mako (*Isurus oxyrinchus*; Corrigan et al., 2018; Francis et al., 2018; and *Isurus paucus*; Estupiñán-Montaño and Delgado-Huertas, 2022), manta ray (*Mobula birostris*), and blue shark (*Prionace glauca*; Coelho et al., 2018). The whale shark (*Rhincodon typus*) is also circumglobal in distribution, and the Pacific Equatorial Front Important Shark and Ray Area (ISRA), an important habitat for whale sharks, overlaps with the CCZ.[32]

While the majority of highly migratory sharks are circumglobal in distribution, a few have more restrictive ranges. The common guitarfish *(Rhinobatos rhinobatos*) only overlaps with known deep-sea mining contract areas in the northern Atlantic (Moore, 2017; Pytka et al., 2024), though other guitarfish species may overlap with deep-sea mining sites in the Pacific and Indian Oceans as well.

The pelagic thresher shark (*Alopias pelagicus*) is found throughout the Pacific and Indian Oceans (Arostegui et al., 2020). Meanwhile, the porbeagle shark (*Lamna nasus*) occurs in both the northern Atlantic and southern Indian Ocean (González et al., 2021; Semba et al., 2013), overlapping with hydrothermal-vent mining contract areas on both the Mid-Atlantic Ridge and the Indian Triple-Junction.

Hammerhead sharks (*Sphyrna lewini*, *Sphyrna mokarran* and *Sphyrna zygaena*) tend to be more coastal, but are known to aggregate around seamounts (Gallagher and Klimley, 2018), including the Northern Galapagos Hydrothermal Vents ISRA Area of Interest.[33] This places hammerhead sharks in potential conflict with future cobalt-rich crust and polymetallic sulphide mining operations.

Several shark species participate in diel vertical migrations, following prey species that migrate up from the midwaters, including all three species of thresher shark (Arostegui et al., 2020; Cartamil et al., 2010; Coelho et al., 2015) as well as basking sharks (Sims et al., 2005) and porbeagle sharks (Francis et al., 2015). Seamounts, where cobalt-crust mining may occur, are hotspots for species like silky sharks, which can travel over 27,666 km (Murray et al., 2023; Salinas-de-León et al., 2024). Basking sharks (Sims, 2008; Sims et al., 2005), whale sharks (Sleeman et al., 2010) and manta rays (Stewart et al., 2016) are filter feeders, dependent on healthy plankton populations. Whale shark studies suggest that their ranges may be heavily altered due to climate change (Sequeira et al., 2012, 2014).

Table 2. Cartilaginous fish species listed under CMS with known range overlaps with existing ISA mining leases

Scientific Name	Common Names	CMS Instruments and Appendices[34]	IUCN Red List Status[35]	Potential Range Overlap
Alopias superciliosus	Bigeye thresher shark	CMS App. I & II, Sharks MOU	VU	Circumglobal
Alopias vulpinus	Common thresher shark	CMS App. I & II, Sharks MOU	VU	Circumglobal
Carcharhinus falciformis	Silky shark	CMS App. II, Sharks MOU	VU	Circumglobal
Carcharhinus longimanus	Oceanic whitetip shark	CMS App. I, Sharks MOU	CR	Circumglobal
Carcharodon carcharias	Great white shark	CMS App. I & II, Sharks MOU	CR	Circumglobal
Cetorhinus maximus	Basking shark	CMS App. I & II, Sharks MOU	EN	Circumglobal
Isurus oxyrinchus	Shortfin mako shark	CMS App. II, Sharks MOU	EN	Circumglobal

32 The Web-GIS ISRA Atlas: https://sharkrayareas.org/e-atlas/

33 Ibid

34 See Annex 1 & 2

35 See Annex 3

Scientific Name	Common Names	CMS Instruments and Appendices[34]	IUCN Red List Status[35]	Potential Range Overlap
Isurus paucus	Longfin mako shark	CMS App. II, Sharks MOU	EN	Circumglobal
Mobula birostris	Manta ray	CMS App. I & II, Sharks MOU	EN	Circumglobal
Prionace glauca	Blue shark	CMS App. II, Sharks MOU	NT	Circumglobal
Rhincodon typus	Whale shark	CMS App. I & II, Sharks MOU	EN	Circumglobal
Lamna nasus	Porbeagle	CMS App. II, Sharks MOU	VU	Atlantic
Rhinobatos rhinobatos	Common guitarfish	CMS App. I (Mediterranean population) & II, Sharks MOU	CR	Atlantic
Alopias pelagicus	Pelagic thresher shark	CMS App. I & II, Sharks MOU	EN	Pacific and Indian
Sphyrna lewini	Scalloped hammerhead shark	CMS App. I & II, Sharks MOU	VU	Circumglobal
Sphyrna mokarran	Great hammerhead shark	CMS App. I & II, Sharks MOU	EN	Circumglobal
Sphyrna zygaena	Smooth hammerhead shark	CMS App. II, Sharks MOU	VU	Circumglobal

While these 18 species comprise the totality of CMS-listed chondrichthyans whose ranges overlap with potential deep-sea mining sites, there are many other highly migratory cartilaginous fishes that are not listed, which may experience impacts from deep-sea mining operations. These include deep-sea shark, skate, ray or chimera species, none of which are CMS-listed, which are known to occur throughout the deep abyssal plain. Pacific sleeper sharks (*Somniosus pacificus*), which have similarly large ranges compared to their pelagic relations, and are known to engage in long vertical and horizontal migrations, are relatively understudied (Tian et al., 2024).

Potential Impacts and Associated Knowledge Gaps

Shark species will interact with deep-sea mining operations in a variety of ways as they traverse the open ocean. With limited surface observations from contractors operating within deep-sea mining contract areas, the extent to which chondrichthyans come in direct contact with mining vessels cannot yet be evaluated. Major knowledge gaps include the effects of sustained, low-frequency noise on pelagic species, the extent to which chemical changes in the water column induced by the mining plume may alter the behaviour of chondrichthyans and their prey, and the impacts of mining on chondrichthyans at seamount habitats and hydrothermal vents.

Fish Aggregation Devices. Stationary vessels in the open ocean act as fish aggregating devices (Røstad et al., 2006). Both chondrichthyans and their prey will be attracted to the mining vessel on station, potentially disturbing foraging, migration, reproduction, and other migratory shark and ray behaviour.

Noise. Although sound can propagate far further than electrical or chemical cues, the impacts of noise, both natural and anthropogenic, on cartilaginous fish has been relatively poorly studied. Early deterrence studies in the 1960s and 1970s suggested that low-frequency sounds may attract sharks (Nelson and Johnson, 1972) while natural sounds that mimic predators like orcas, as well as sudden, high frequency sounds, may repel them (Myrberg et al., 1978). In more recent studies, coastal shark species demonstrated avoidance behaviour when exposed to both artificial low-frequency sound and sounds designed to mimic orca vocalizations, while the highly migratory great white shark demonstrated avoidance behaviour only in the presence of low-frequency sound (Chapuis et al., 2019). Furthermore, great white sharks did not develop a tolerance to low-frequency sound, even after prolonged exposure.

A recent study suggests that some shark species may vocalize through clicking their tooth plates, a behaviour which, if supported by more studies, could suggest that chronic sound exposure could impair communication of select species (Nieder et al., 2025). Effects on the ocean soundscape by deep-sea mining equipment is increasingly recognized as a major source of disturbance for soniferous species that interact with mining areas (Williams et al., 2025).

Plumes. Relatively little is known about the impacts of midwater and deep-sea plumes on chondrichthyans. The presence of a midwater or surface plumes produced by mining activity may alter chemical signals that cartilaginous fish use to detect prey. It could also adversely affect midwater prey species that sharks and rays feed upon. Increased suspended sediment concentrations can be a major stressor for marine animals (van der Grient and Drazen, 2022).

Habitat Destruction. Habitat destruction is likely the most direct threat to cartilaginous fish that use seamounts for foraging and nursery grounds. Sharks, however, are very rarely found below 3,000 metres (Priede et al., 2006), though a couple of species occur at depths of up to 4,000 metres. Nodule mining is therefore unlikely to affect benthic habitat for these animals.

In at least one instance, deep-sea skates have been documented depositing their egg cases in close proximity to an active hydrothermal vent (Salinas-de-León et al., 2018). Researchers hypothesized that the skates are taking advantage of the elevated temperature around the vent site to incubate their eggs and accelerate development. Catshark and skate egg cases have also been discovered at both contemporary and fossil deep-sea cold seeps (Treude et al., 2011). The mining of polymetallic sulphides could result in the comprehensive removal of these important deep-ocean nurseries.

Climate Change. Climate change induced shifts in ocean temperature, prey distribution and availability of habitat will result in changes in the distribution and diversity of shark species across the ocean (Santos et al., 2024), leading to increased or decreased interactions with deep-sea mining operations. While relatively little is known about the global extent of the distribution of deep-sea sharks, rays and chimera, at least one study proposes that habitat changes and range expansions for the Pacific sleeper shark (Somniosus pacificus) are the result of climate change and other anthropogenic influences (Tian et al., 2024). As the largest known mobile megafauna of the deep sea, sharks, skates, rays and chimera may play an outsized role in the recovery, or lack thereof, of mining sites following exploitation – yet the data on their distribution and ecology is limited.

Actinopterygii (Bony Fish)

Many highly migratory bony fish species, including commercially important fishes like tuna, swordfish and billfish, have ranges that overlap with proposed deep-sea mining sites. However, the majority of those species are not CMS-listed and are covered under other treaties, such as the Convention for the Conservation of Southern Bluefin Tuna and the United Nations Fish Stocks Agreement.[36] Of the 23 bony fishes listed under the Convention, only the European eel (*Anguilla anguilla*) has a range known to overlap with potential or proposed deep-sea mining sites.

European eels are catadromous fish that migrate more than 5,000 km across the Atlantic to spawn in the Sargasso Sea at depths of between 0 to 700 metres. Larval eels then migrate across the Atlantic to settle in European rivers, though some individuals never return to freshwater and instead remain in coastal seas and brackish estuaries (Arai, 2020). Larval eels may take more than two years to migrate from the Sargasso Sea back to the European continental shelf (Bonhommeau et al., 2010, 2009). After 5 to 25 years, adult European eels return to the Sargasso Sea to spawn, after which they die. How European eels navigate across the Atlantic to their spawning grounds is not well understood, but is likely a combination of lunar, magnetic and chemical cues (Cresci, 2020).

The European eel is found throughout European rivers and coasts as well as in the Mediterranean, and is the most widespread single fish stock in Europe. Eel populations have been declining since the mid-nineteenth century and recruitment from the oceans to the continental shelf has fallen to as little as 1% of its former levels (Dekker, 2019). The European eel is listed as Critically Endangered by the IUCN.

While only the European eel is CMS-listed, other anguillid species would also be affected by deep-sea mining. The American eel (*Anguilla rostrata*) has a similar migration and life history as its European counterpart (Jessop, 2010). New Zealand longfin eel (*Anguilla dieffenbachia*), Australian speckled longfin (*Anguilla reinhardtii*) and shortfin eel (*Anguilla australis*) likewise spawn in the deep waters of the Pacific Ocean before returning to coastal riverine habitats

Table 3:Bony fish species listed under CMS with potential range overlaps with existing ISA or national mining leases

Scientific Name	Common Names	CMS Instruments and Appendices[37]	IUCN Red List Status[38]	Potential Range Overlap
Anguilla anguilla	European eel; River eel; Weed eel	CMS App. II	CR	Atlantic – from coastal Europe to the Sargasso Sea

Potential Impacts and Associated Knowledge Gaps

During their migration to the Sargasso Sea as adults, and from the Sargasso Sea as larvae, European eels may pass over polymetallic sulphides on the Mid-Atlantic Ridge. These include ISA contract areas in the northern Mid-Atlantic issued to France, the Russian Federation and the Republic of Poland.

Noise. Noise from both mining activity and from the dynamic positioning systems used by mining vessels could have adverse impacts on European eel migration. Low-frequency sound is known to disrupt eel navigation and has been employed as a deterrent to prevent European eels from entering water intakes at hydropower stations, with mixed results (Piper et al., 2019). Anthropogenic noise has been shown to reduce European eels' response time, making them more susceptible to predation (Simpson et al., 2015).

While European eels are the only CMS-listed Actinopterygii whose range overlaps with potential deep-sea mining sites, numerous migratory fish species that occur within areas like the Clarion-Clipperton Zone are known to use sound for communicating or navigation, and may be adversely affected by the chronic noise produced by deep-sea mining operations (Williams et al., 2025).

Plumes. The presence of midwater or surface plumes produced by mining activity may alter chemical signals that European eels use to navigate towards their spawning grounds. Eels have high olfactory sensitivity, which is used for chemical communication, particularly during reproduction (Huertas et al., 2008). Plumes may also impact respiration by clogging gills or alter the behaviour of prey species.

Major knowledge gaps for European eels revolve around the 5,000-kilometre adult migration from the European continental shelf to the Sargasso Sea where they spawn and the larval migration back. At some point during this

36 The United Nations Fish Stocks Agreement https://www.un.org/oceancapacity/unfsa

37 See Annex 1 & 2

38 See Annex 3

journey, migrating eels must pass over the northern Mid-Atlantic Ridge, where at least three mining contractors are actively developing mining sites. The questions of how noise and plumes impact eel migration can inform deep-sea mining management, these are fundamental knowledge gaps related to the ecology of the species, as well as specific to the impacts of deep-sea mining.

Picture 7. European Eel © Adobe Stock Images

Reptilia (Sea Turtles)

Of the nine CMS-listed marine reptiles, five species of sea turtle occur in IUCN Marine Turtle Regional Management Units that overlap with potential or proposed deep-sea mining sites.[39] The green sea turtle (*Chelonia mydas*), leatherback turtle (*Dermochelys coriacea*), hawksbill turtle (*Eretmochelys imbricata*) and loggerhead turtle (*Caretta caretta*) have circumglobal ranges that may overlap with ISA-issued contract areas in the Pacific, Indian and Atlantic Oceans. Olive ridleys (*Lepidochelys olivacea*) range across ISA contract areas in the Pacific and Southern Atlantic. The Kemp's ridley (*Lepidochelys kempii*) does not currently overlap with ISA contract areas; however, climate change-induced range shifts may result in future overlaps.

Five of the seven known sea turtle species are widely distributed across the world. Leatherback, green, loggerhead, hawksbill and olive ridley sea turtles are found nesting on every continent except Antarctica (Hendrix and Pérez-Espona, 2024). While globally distributed, sea turtle populations are predominantly coastal, with strong natal homing drawing them back to the same beach to nest every year. However, sea turtles are slow to mature, and immature and sub-adult sea turtles are highly migratory, traveling, in some cases, thousands of kilometres across the open ocean before returning to their natal home. Tracking the migration of sea turtles largely entails tagging females during nesting, which means there are significant gaps in the data on the migration of immature turtles (Hendrix and Pérez-Espona, 2024).

Green, leatherback, hawksbill, loggerhead and olive ridley turtles are circumglobal in their migration and distribution, with the potential to occur within all known deep-sea mining leases. Though primarily coastal in adulthood, immature green sea turtles have a pelagic stage, migrating thousands of kilometres in the open ocean for at least a year before returning to coastal habitats (Pelletier et al., 2003) as they transition from omnivorous to herbivorous feeding behaviours (Williard et al., 2017).

Leatherback turtles cross the Atlantic (Fossette et al., 2010; James et al., 2005; Rider et al., 2024), Pacific (Piboon et al., 2025) and Indian Oceans. Leatherback populations in the Pacific Ocean are among the most vulnerable sea turtle populations and undertake critical migrations through the CCZ and other regions of the Pacific where deep-sea mining may occur (Lopez et al., 2024).

Hawksbill turtles can have long migratory periods that may span more than 1,200 kilometres (Hawkes et al., 2012). They are found throughout the Atlantic (Maurer et al., 2024), Pacific (Van Houtan et al., 2016) and Indian Oceans (Fossette et al., 2021). Loggerhead turtles have a similarly circumglobal range (Witt et al., 2010). The olive ridley is the most abundant of all the sea turtles, and is found

Table 4. Reptile species listed under CMS with known range overlaps with existing ISA mining leases

Scientific Name	Common Names	CMS Instruments and Appendices[40]	IUCN Red List Status[41]	Potential Range Overlap
Caretta caretta	Loggerhead turtle	CMS App. I, IOSEA Marine Turtles MOU, Atlantic Turtles MOU	VU	Circumglobal
Chelonia mydas	Green turtle	CMS App. I, IOSEA Marine Turtles MOU, Atlantic Turtles MOU	EN	Circumglobal
Dermochelys coriacea	Leatherback turtle, leathery turtle	CMS App. I, IOSEA Marine Turtles MOU, Atlantic Turtles MOU	VU	Circumglobal
Eretmochelys imbricata	Hawksbill turtle	CMS App. I, IOSEA Marine Turtles MOU	CR	Circumglobal
Lepidochelys kempii	Kemp's ridley turtle, Atlantic ridley turtle	CMS App. I, Atlantic Turtles MOU	CR	Atlantic (range expanding due to climate change)
Lepidochelys olivacea	Ridley turtle, olive ridley turtle	CMS App. I, IOSEA Marine Turtles MOU, Atlantic Turtles MOU	VU	Circumglobal

39 Regional Management Units: https://www.iucn-mtsg.org/regional-management-units

40 See Annex 1 & 2

41 See Annex 3

across all tropical regions of the Atlantic, Pacific and Indian Oceans. Olive ridleys are notable for their massive arribada nesting events, where thousands of turtles may emerge simultaneously to nest on the same beach (Cáceres-Farias et al., 2022).

Kemp's ridley turtles present an interesting case for future interactions. Though the limited range of this species does not currently overlap with current or planned mining contract areas, climate-induced range expansion has resulted in an increasing number of cases of Kemp's ridleys migrating across the Atlantic (Pike, 2013), potentially bringing future populations into contact with ISA-issue mining contract areas on the Mid-Atlantic Ridge.

Potential Impacts and Associated Knowledge Gaps

During oceanic migrations, loggerhead, leatherback, green, hawkbill and olive ridley sea turtles may pass through ISA-issued polymetallic sulphide contract areas on the Mid-Atlantic Ridge, as well as cobalt-rich crust and polymetallic nodule contract areas in the Pacific and Indian Oceans. All five species may also encounter deep-sea mining sites within territorial waters, including in the waters of India, China, Japan and American Samoa.

With limited surface observations from contractors operating within deep-sea mining contract areas, the extent to which sea turtles come in direct contact with mining vessels cannot currently be evaluated.

Noise. Noise from both mining activity and from the dynamic positioning systems used by mining vessels could have adverse impacts on sea turtle behaviour (Williams et al., 2025). These operations are anticipated to run 24-hours a day over a variety of ocean depths throughout the course of months or years (Thompson et al., 2023). During migration, anthropogenic vessel noise has been demonstrated to increase vigilance in sea turtles, suggesting a stress response in the presence of chronic and acute noise (Díaz et al., 2024). Sea turtles may be particularly sensitive to low-frequency sound common to seismic surveys and which may be produced throughout the water column by deep-sea mining operations (van der Wal et al., 2016).

Plumes. The presence of midwater or surface plumes produced by mining activity may alter chemical signals that sea turtles use to navigate and detect prey. Increased suspended sediment concentrations can be a major stressor for marine animals (van der Grient and Drazen, 2022), impacting their ability to detect visual cues, disturbing feeding, and altering the behaviour of prey species. Leatherback turtles, for example, are primarily deep-diving gelativores and studies have shown that gelatinous plankton are susceptible to turbidity as would be caused by midwater sediment plumes (Stenvers et al., 2020).

Ship Strikes. For many sea turtle species, ship strikes can be a significant cause of mortality, particularly around nesting beaches and foraging grounds (Denkinger et al., 2013; Welsh and Witherington, 2023). There is relatively limited available data on the impacts of vessel strikes on species and populations other than cetaceans (Vighi, 2025) or on sea turtles during migration.

Climate Change. The effects of climate change on the future impacts of deep-sea mining on sea turtle migration is poorly understood. For example, while the range of the Kemp's ridley is predominantly restricted to the Gulf of Mexico and the Atlantic coast of North America, rising sea temperatures are expanding its range (Pike, 2013). Individuals have recently been documented as far north as Wales and the Netherlands (Manral et al., 2024). Ongoing climate-induced range expansion will increase the overlap between Kemp's ridley migration routes and potential deep-sea mining sites on the Mid-Atlantic Ridge.

Picture 8. Ruddy Turnstone observed during Seabird Surveys Across the Pacific with SPREP Scientists. © Ocean Exploration Trust/NOAA

Aves (Seabirds)

Seabirds migrate through Ecologically or Biologically Significant Marine Areas (EBSAs) and marine Important Bird Areas (IBAs) that overlap with proposed and potential deep-sea mining sites. These include the North Pacific Transition Zone, which encompasses the CCZ, as well as the Mid-North-Atlantic Frontal System, Charlie-Gibbs Fracture Zone, North Azores Plateau, Southern Reykjanes Ridge and Central Indian Ocean Basin.[42] Many migratory seabirds which are not CMS-listed species also interact with and travel through these areas.

Of the 388 CMS-listed bird species, 27 have potential range overlaps with current or proposed deep-sea mining contract areas in either international or national waters. The majority of these species are found nesting or migrating through New Zealand territorial waters. These include the grey (*Procellaria cinerea*), black (*Procellaria parkinsoni*), white-chinned (*Procellaria aequinoctialis*) and westland petrel (*Procellaria westlandica*), and the Buller's (*Thalassarche bulleri*), grey-headed (*Thalassarche chrysostoma*), Chatham (*Thalassarche eremita*), Campbell (*Thalassarche impavida*), black-browed (*Thalassarche melanophris*), Salvin's (*Thalassarche salvini*) and white-capped albatrosses (*Thalassarche steadi*; Phillips et al., 2016). Though New Zealand has no current plans to mine polymetallic nodules, polymetallic sulphides or cobalt-rich crusts, recent efforts have been made to mine vanadium in the Taranaki Bight;[43] a bay that reaches depths of 500 metres, and initial work has been conducted to explore the potential for future mining of crusts and sulphides within the country's EEZ.

The wandering albatross's (*Diomedea exulans*) range extends into the Pacific, Atlantic and Indian Oceans, and individuals may cover hundreds of thousands of kilometres throughout their migration (Burg and Croxall, 2004; Weimerskirch et al., 2006). Other albatrosses are more restricted, with the yellow-nosed (*Thalassarche chlororhynchos*) and Tristan albatross (*Diomedea dabbenena*) found in the southern Atlantic (Morten et al., 2025). Atlantic albatrosses may interact with deep-sea mining leases on the Mid-Atlantic Ridge, though their southern bias makes contact with current mining contract areas unlikely. The Bermuda petrel (*Pterodroma cahow*) is limited to the islands of Bermuda, but its foraging range may overlap with mining operations on the Mid-Atlantic Ridge (Raine et al., 2021).

42 IBAs & EBSAs – Describing important at-sea areas: https://www.seabirdtracking.org/case-studies/ibas-and-ebsas/

43 New Zealand debates second seabed mine in push to double mineral exports: https://www.mining-technology.com/news/new-zealand-debates-second-seabed-mine-in-push-to-double-mineral-exports/

In the Pacific, short-tailed (*Phoebastria albatrus*; Piatt et al., 2006), black-footed (*Phoebastria nigripes*; Morten et al., 2025) and Laysan albatrosses (*Phoebastria immutabilis*; Morten et al., 2025) are known to occur within the Clarion-Clipperton Zone, along with pink-footed shearwaters (*Ardenna creatopus*; Morten et al., 2025) and dark-rumped petrels (*Pterodroma sandwichensis*; Raine et al., 2025). Antipodean albatrosses (*Diomedea antipodensis*; Morten et al., 2025) have a more southerly range but may overlap with planned deep-sea mining contract areas in the South Pacific. The waved albatross (*Phoebastria irrorata*) has a similar southern bias, but its range does overlap with the DISCOL experimental deep-sea mining site off the coast of Peru (Fernández et al., 2001).

In the Indian Ocean, the range of the Indian yellow-nosed albatross (*Thalassarche carteri*) may overlap with mining contract areas on the Indian Triple-Junction (Morten et al., 2025). The Christmas Island frigatebird (*Fregata andrewsi*; Dutson, 2001) and great crested tern (*Thalasseus bergii*; Collinson et al., 2017) may also interact with mining contract areas in the Indian and Pacific Oceans.

The Amsterdam albatross (*Diomedea amsterdamensis*) also occurs within the Indian Ocean. It has only been found on one island, and while its range is largely unknown, it could overlap with ISA-issued mining leases in the Indian Ocean (Rains et al., 2011). The Steller's sea-eagle (*Haliaeetus pelagicus*) has a vagrant range that overlaps with experimental seabed mining sites within Japan's EEZ (Ueta et al., 2000).

Table 5. Seabird species listed under CMS with known range overlaps with existing ISA mining leases

Scientific Name	Common Names	CMS Instruments and Appendices[44]	IUCN Red List Status[45]	Potential Range Overlap
Ardenna creatopus	Pink-footed shearwater	CMS App. I, ACAP	VU	Clarion-Clipperton Zone
Diomedea amsterdamensis	Amsterdam albatross	CMS App. I, ACAP	EN	Unknown
Diomedea antipodensis	Antipodean albatross	CMS App. I & II, ACAP	EN	Pacific
Diomedea dabbenena	Tristan albatross	CMS App. II, ACAP	CR	South Atlantic
Diomedea exulans	Wandering albatross	CMS App. II, ACAP	VU	South Atlantic, Pacific and Indian
Fregata andrewsi	Christmas Island frigatebird, Andrews' frigatebird	CMS App. I	VU	Indian
Haliaeetus pelagicus	Steller's sea-eagle	CMS App. I	VU	Unknown
Phoebastria albatrus	Short-tailed albatross, Steller's albatross	CMS App. I, ACAP	VU	Clarion-Clipperton Zone
Phoebastria immutabilis	Laysan albatross	CMS App. II, ACAP	NT	Clarion-Clipperton Zone
Phoebastria irrorata	Waved albatross	CMS App. II, ACAP	CR	Pacific, near DISCOL experimental mining site
Phoebastria nigripes	Black-footed albatross	CMS App. II, ACAP	NT	Clarion-Clipperton Zone
Procellaria aequinoctialis	White-chinned petrel	CMS App. II, ACAP	VU	New Zealand
Procellaria cinerea	Grey petrel	CMS App. II, ACAP	NT	New Zealand
Procellaria parkinsoni	Black petrel	CMS App. II, ACAP	VU	New Zealand
Procellaria westlandica	Westland petrel	CMS App. II, ACAP	EN	New Zealand

44 See Annex 1 & 2

45 See Annex 3

Scientific Name	Common Names	CMS Instruments and Appendices[44]	IUCN Red List Status[45]	Potential Range Overlap
Pterodroma cahow	Cahow, Bermuda petrel	CMS App. I	EN	Mid-Atlantic Ridge
Pterodroma sandwichensis	Dark-rumped petrel, Hawaiian petrel, Uau	CMS App. I	EN	Clarion-Clipperton Zone
Thalassarche bulleri	Buller's albatross	CMS App. II, ACAP	NT	New Zealand
Thalassarche carteri	Indian yellow-nosed albatross	CMS App. II, ACAP	EN	Indian
Thalassarche chlororhynchos	Yellow-nosed albatross	CMS App. II, ACAP	EN	Mid-Atlantic Ridge
Thalassarche chrysostoma	Grey-headed albatross	CMS App. II, ACAP	EN	New Zealand
Thalassarche eremita	Chatham albatross	CMS App. II, ACAP	VU	New Zealand
Thalassarche impavida	Campbell albatross	CMS App. II, ACAP	VU	New Zealand
Thalassarche melanophris	Black-browed albatross	CMS App. II, ACAP	LC	New Zealand
Thalassarche salvini	Salvin's albatross	CMS App. II, ACAP	VU	New Zealand
Thalassarche steadi	White-capped albatross	CMS App. II, ACAP	NT	New Zealand
Thalasseus bergii	Great crested tern	CMS App. II, AEWA	LC	Indian and Pacific

Potential Impacts and Associated Knowledge Gaps

Migratory seabirds may pass through a variety of different deep-sea mining contract areas, including those issued by the ISA in the Atlantic, Pacific and Indian Oceans, as well as within national waters. As bycatch in commercial fishing gear is the greatest threat to migratory seabirds, the direct impacts of deep-sea mining operations are likely to be relatively less significant, compared to other CMS-listed groups. The extent to which consistent marine flyways (Morten et al., 2025) overlap with current and future deep-sea mining sites may result in increased contact between migratory seabirds and mining operations.

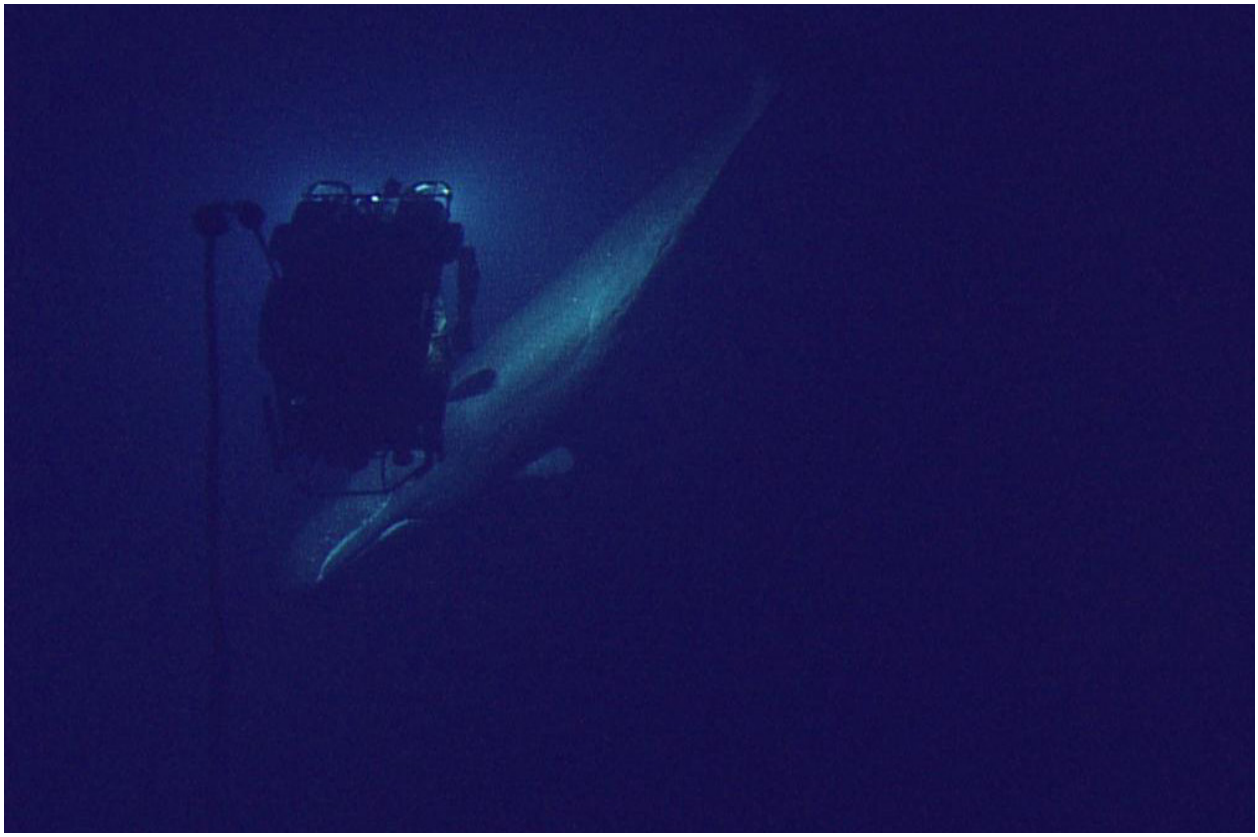
Fish Aggregating Devices. Stationary vessels in the open ocean act as fish aggregating devices (Røstad et al., 2006). Prey species will be attracted to the mining vessel on station, potentially disturbing seabird feeding behaviour. Long-term studies on the presence of consistent fish aggregation around stationary mining vessels and their impacts on migration are needed.

Offshore Structures. Deep-sea mining vessels held stationary over a relatively long duration may act like offshore structures in terms of their attractiveness to migratory bird species. Light and gas flares from offshore oil and gas infrastructure is known to attract seabirds, especially during periods when weather and visibility are poor (Ronconi et al., 2015). Lights produced by deep-sea mining vessels operating around the clock could attract migrating seabirds. Conversely, the abundance and density of seabirds has declined following the installation of offshore wind farms (Garthe et al., 2023), including during seabird breeding seasons (Peschko et al., 2020).

Whether migratory seabirds are attracted to stationary deep-sea mining vessels, either because they act as offshore structures or attract prey species, or avoid these operations as they do with offshore windmills, remains to be seen.

Closing Summary

While deep-sea mining will pose varied and direct threats to highly migratory species, the full extent of those impacts is poorly quantified. The production of sediment plumes, chronic noise pollution and direct removal of benthic habitat can have far-reaching impacts on the migration, feeding, reproduction and social behaviour of many marine animals. Increased vessel traffic in relatively quiet areas can result in an increased risk of ship strikes. Stationary vessels operating for long durations can act as fish aggregating devices that attract migratory predators, resulting in alterations to feeding and migration. More research is needed to comprehensively characterize the impact of this nascent industry on CMS-listed and other highly migratory species. The ISA and mining contractors are in a unique position to assist in the widespread and transparent collection of data.



Picture 9. Sperm whale interacts with an ROV at 600 meters depth. © Ocean Exploration Trust/NOAA

Annexes

Annex 1 – CMS Agreements mentioned in the text

Agreement	Abbreviation
ACAP	Agreement on the Conservation of Albatrosses and Petrels
ACCOBAMS	Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area
AEWA	Agreement on the Conservation of African-Eurasian Migratory Waterbirds
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas

Annex 2 – CMS Memoranda of Understanding (MOU) mentioned in the text

MOU	Abbreviation
Atlantic Turtles MOU	Memorandum of Understanding concerning Conservation Measures for Marine Turtles of the Atlantic Coast of Africa
IOSEA Marine Turtles MOU	Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia
Monk Seal MOU	Memorandum of Understanding concerning Conservation Measures for the Eastern Atlantic Populations of the Mediterrane-an Monk Seal (Monachus monachus)
PIC MOU	Memorandum of Understanding for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region
Sharks MOU	Memorandum of Understanding on the Conservation of Migratory Sharks
WAAM MOU	Memorandum of Understanding concerning the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaro-nesia

Annex 3 – International Union for Conservation of Nature (IUCN) Red List Status Abbreviations

Red List Status	Abbreviation
Data Deficient	DD
Least Concern	LC
Near Threatened	NT
Vulnerable	VU
Endangered	EN
Critically Endangered	CR
Extinct in the Wild	EW
Extinct	EX
Not Evaluated	NE

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The Convention on the Conservation of Migratory Species of Wild Animals (CMS)

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