



# Deep-Sea Mining: International Regulatory Challenges and Responses

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**D**eep-sea mining presents complex regulatory challenges due to its multi-faceted political, economic, technological, scientific, environmental, social, industrial and legal aspects. These must all be sensitively addressed to achieve a commercially viable and socially responsible industry. Furthermore, these aspects are either governed by, or must take into account, the burgeoning regulatory regime promulgated by the International Seabed Authority. This paper addresses the regulatory challenges associated with the three types of deep-ocean mineral deposits of greatest interest to the deep-sea mining industry: polymetallic nodules, ferromanganese crusts, and polymetallic sulfides. We review current resource interest, the international regulatory context, selected regulatory challenges, and the International Seabed Authority's innovative responses to selected issues.

**KEYWORDS:** deep-sea mining, exploration, exploitation, regulatory, environment, sustainability

## INTRODUCTION

There are three main types of deep-sea mineral resources, introduced by Lusty and Murton (2018 this issue), that are currently attracting most interest. Each represent distinct classes of metal-bearing mineral deposits which occur in distinctive biogeophysical deep-sea environments. The three types of deep-sea mineral resources under discussion are polymetallic nodules ('Fe-Mn' nodules), ferromanganese crusts and polymetallic sulfides (i.e. seafloor massive sulfides). Each type of deposit presents individual technical, environmental, and regulatory challenges at every stage of the exploration and exploitation cycle. These challenges derive from the following factors:

- 1) the physical nature and expression of the deposit itself (considered by Jones et al. (2018 this issue));
- 2) the biogeophysical environment of each deposit type: abyssal plain sediments for nodules; rocky seamounts and ridges for crusts; and hydrothermal vent systems for seafloor massive sulfides;
- 3) the geographic location of the deposit.

## ENVIRONMENTAL ASPECTS

The most significant environmental challenges and impacts of deep-sea mining as summarized by Jones et al. (2018 this issue) are briefly reiterated here because they form one of

the principal regulatory challenges facing the International Seabed Authority. These environmental challenges, and the International Seabed Authority's response, also present technical challenges (not addressed here) for the deep-sea mining industry.

An extensive and rapidly growing body of scholarly literature addresses the potential effects on the marine environment of deep-sea mining. These effects are usually addressed in one or more of three contexts common to the three mineral resources under discussion: the surface, in the water column, and at and below the seafloor. The surface and the

water-column effects are likely to be similar for all three resource types. The most extensive effects, i.e. those with the most potentially long-term consequences, are likely to occur at the seafloor.

The principal environmental impacts and the main environmental advantages of deep-sea mining are summarized in TABLE 1. It must be emphasized that deep-sea mining, considered both on its own and in the context of the overall global stressors on the health of this planet, has much to offer that is environmentally constructive.

## INTERNATIONAL LEGAL AND REGULATORY CONTEXT

One regulatory challenge shared by all three deposit types is their location on and below the seabed, far offshore: at least 25 nautical miles from land (i.e. outside the 12 nautical mile territorial sea) and usually much further out to sea (i.e. beyond 100 nautical miles in the Exclusive Economic Zone). The Exclusive Economic Zone extends 200 nautical miles from a fixed baseline, which under international law is usually the low-water line along the coast (as marked on official charts of the relevant coastal state) and on the (outer) continental shelf (which may, under certain circumstances not addressed here, extend out to 350 nautical miles or to 100 nautical miles from the 2,500 m isobath), and includes sea areas beyond any national jurisdiction (i.e. the so-called 'high seas') (Fig. 1). The deposits of greatest commercial interest are found in the Pacific, Indian, and Atlantic Oceans, listed here in order of geological prospectivity (mineral potential) and associated economic interest based on current knowledge. To date, the most commercially significant resources have primarily been found outside national jurisdiction, which under international law triggers application of an international regulatory regime, of which a brief overview follows.

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**TABLE 1** PRINCIPAL ENVIRONMENTAL IMPACTS AND ADVANTAGES OF SEABED MINING

**Environmental Impacts of Seabed Mining**

- permanent removal of hard substrate required by certain organisms/faunal communities
- effects of sediments, wastes, and other effluents (at bottom, mid-water and surface)
- noise
- vibration
- light
- leaks, spills, the effects of infrastructure corrosion
- operational discharges from the surface vessels\*
- slow and different biological regeneration (especially of sessile communities)
- uncertain remediation potential
- vessel traffic for ore transport to shore\* for land-based processing
- vessel-source air pollution\*
- surface and mid-water marine community disturbance, especially if mining vessels remain on location for many months

**Environmental Advantages of Seabed Mining (Contrasted with Terrestrial Mining)**

- little or no overburden to remove (e.g. overlying rock, soil, vegetation cover)
- ore grades can be significantly higher than on land, meaning that less ore is required to provide the same amount of metal
- multiple metals can be obtained from a single site due to polymetallic nature of deposits
- no local human populations to be disrupted
- no permanent infrastructure

\* governed by International Maritime Organization treaties and regulations, which are not addressed in this article

**The United Nations Law of the Sea Convention**

The United Nations Law of the Sea Convention (LOSC) is our world's "Constitution for the Oceans" (Koh 1983). Negotiated over nearly ten years, it entered into force on 16 November 1994; as of 1 February 2018, it has 168 parties. Comprised of 320 Articles and 9 Annexes, it is one of the longest and most complex multi-lateral treaties concluded to date. Furthermore, it is, as of 2018, the most powerful and comprehensive treaty governing human activities on this planet. No terrestrial (land-based) equivalent exists. The Law of the Sea Convention aims to have an all-inclusive scope with regard to law of the sea issues (see Preamble, first paragraph). Because it applies also to land-based and

atmospheric activities when the marine environment is or may be adversely affected, its remit in this context spans the planet.

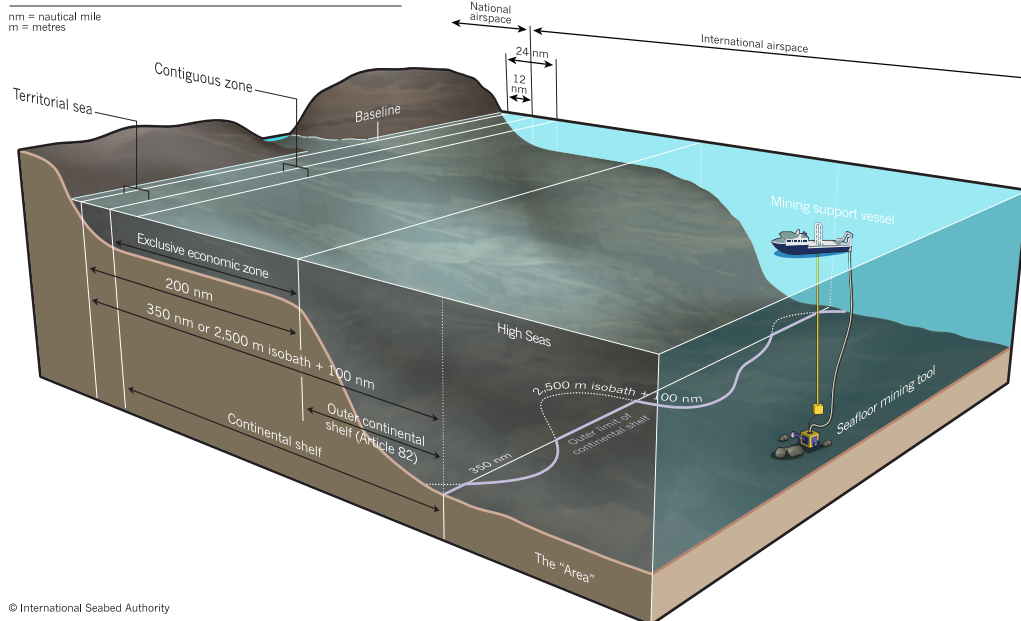
Of particular note is the profound concern of the drafters of the Law of the Sea Convention for the marine environment (Box 1). In addition to an entire chapter (Part XII) (see below) being dedicated to this subject, the first Article addresses the marine environment by setting out an all-encompassing definition of 'pollution of the marine environment'. Note that this definition applies to anthropogenic CO<sub>2</sub> emissions, regardless of their source. In the environmental context, there is also extensive use of the precautionary words 'may' [e.g. LOSC Articles 119 1.(b); 145; 196; 206] and 'likely' [e.g. LOSC Articles 1 1.(1)(4); 198; 204(2)] in provisions designed to establish circumstances under which action to protect and preserve the marine environment is required.

An essential source of the Law of the Sea Convention's power is that its provisions are usually mandatory, unqualified, and without exceptions. The unqualified nature of the provisions is illustrated by the virtual absence of phrases such as 'in accordance with capabilities', 'as appropriate', 'as far as possible', 'as far as practicable,' whose use in treaties, even when coupled with 'shall', unfortunately tend to negate in practice these treaties' obligatory intentions. For example, Article 309 explicitly prohibits reservations or exceptions and Article 310 reinforces this prohibition for states becoming parties to the Law of the Sea Convention. Finally, many of its provisions are now considered to have codified, or become part of, customary international law, thereby making it exceedingly difficult under international law for non-parties to act inconsistently with those provisions.

**The Law of the Sea Convention and Deep-Sea Mining**

We address here the Law of the Sea Convention provisions applicable to the mineral resources found in areas beyond national jurisdiction. Of these, the most important are LOSC Part XI, LOSC Annexes III and IV, and the 1994 Agreement Relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea. Note the Law of the Sea Convention's definitions of the 'Area', 'activities in the Area', 'resources of the Area': these definitions

Maritime space under the 1982 United Nations Convention on the Law of the Sea.



**FIGURE 1** Maritime space as defined under the 1982 United Nations Convention on the Law of the Sea. IMAGE: INTERNATIONAL SEABED AUTHORITY.

**Part XI (Area); Annex III (Basic Conditions of Prospecting, Exploration and Exploitation); Part XI (Implementing Agreement)**

- Part XI (Article 145): Prevent/reduce/control pollution and other hazards to and interference with ecological balance of the marine environment; protect and conserve *natural* resources of the Area and prevent damage to flora and fauna of the marine environment
- Part XI (Article 147(1) and (3)): Conduct other activities in the Area *and in the marine environment* with reasonable regard for mineral activities and *vice-versa*
- Annex III Article 17 – sets out what the International Seabed Authority must regulate: Marine environment: (1)(b)(xii) and 2(f)
- Annex III Article 14(2): Marine environmental data are not proprietary
- Implementing Agreement: Preamble; Section 1(g), (h), (i), (k)

**Part XII (Protection and Preservation of the Marine Environment)**

- Article 192: “States have the obligation to protect and preserve the marine environment.”
- Article 194(5): measures required to protect and preserve rare or fragile ecosystems [and] depleted, threatened or endangered species and other forms of marine life
- Articles 204 and 206: require both environmental impact assessment and monitoring
- Article 209: marine environmental protection requirements specifically for the Area; includes flag states
- Article 215: enforcement of marine environmental protection rules in the Area (see also Article 153(5) Part XI)

**Part XIII (Marine Scientific Research)**

- Article 240(d): Marine scientific research is subject to Part XII (marine environmental protection) rules (see also Article 87(1): on ‘high seas’ freedoms, which include marine scientific research; their exercise is not unrestricted; all ‘high seas’ freedoms must be exercised with due regard for activities in the Area (Article 87(2)).
- Article 256: Marine scientific research may be conducted in the Area (see also Article 87(2) and Part XI Article 143) by the International Seabed Authority, state parties and other competent international organizations
- Articles 242 and 243: International cooperation in general and between the International Seabed Authority, state parties and contractors in particular on marine scientific research is encouraged, especially on the marine environment and related research (see also Article 143 on marine scientific research in the Area). This cooperation is essential for developing and implementing *cumulative* environmental impact management systems.

all relate only to the seabed/subsoil and solid, liquid, or gaseous minerals found in areas beyond national jurisdiction, and thereby set the jurisdiction of the International Seabed Authority, the body set up under the Law of the Sea Convention (Part XI Section 4), to administer activities in and the resources of the Area.

**Legal Status of the Area and its Resources**

Both the Area and its resources are designated by LOSC Article 136 as “the common heritage of mankind”, a *sui generis* legal status which entails that no state may exercise sovereignty or sovereign rights over the Area or its resources and that rights in the resources of the Area (i.e. minerals) are “vested in mankind as a whole”, on whose behalf the International Seabed Authority acts (LOSC Article 137(2)), but only for those specific rights. It is important to note that in the context of the Law of the Sea Convention the “common heritage of mankind” denotes only a specific and limited legal status and does not imply any moral or philosophical concept.

**International Tribunal for the Law of the Sea (ITLOS)**

Established pursuant to LOSC Article 287(1)(a) and operating according to its statute under LOSC Annex VI, the International Tribunal for the Law of the Sea (ITLOS; www.itlos.org), is an essential part of the comprehensive scope of the Law of the Sea Convention. Under LOSC

Article 186, the Seabed Disputes Chamber, a chamber of 11 judges, exists as a ‘court within a court’ with specialized jurisdiction over matters relating to deep-sea mining under Part XI of the Law of the Sea Convention. On 1 February 2011, the Chamber issued a pioneering advisory opinion (pursuant to LOSC Article 191) on responsibilities and liabilities of states engaging in or sponsoring marine mining (LOSC Article 139), especially with regard to the marine environment, holding that all states, regardless of their developmental status and financial and technical capabilities, must comply with the Law of the Sea Convention and with the International Seabed Authority’s mining regulations (ITLOS 2011) (Freestone 2011).

**International Seabed Authority**

The International Seabed Authority implements the Law of the Sea Convention on deep-sea mining. It is headquartered in Kingston, Jamaica (www.isa.org.jm). All Law of the Sea Convention parties are members of the International Seabed Authority. The International Seabed Authority has the exclusive mandate to manage seabed minerals in the Area on behalf of ‘mankind as a whole’, and the exclusive right to issue exploration and exploitation contracts for minerals in the Area. It is not empowered to exclude other (non-mineral) activities in the Area, such as marine scientific

research, even in areas for which it has issued an exploration contract. It is not empowered to issue contracts for activities related to other (non-mineral) resources in the Area.

Under the Law of the Sea Convention, exploration for and exploitation of seabed minerals in the Area may only be carried out under a contract with the International Seabed Authority and subject to its rules, regulations and procedures. Contracts may be issued to both public and private mining enterprises provided they are sponsored by a state party to the Law of the Sea Convention and meet certain standards of technological and financial capacity. Ultimately, the economic benefits from deep-sea mining, most likely in the form of royalties paid to the International Seabed Authority, are to be shared for the ‘benefit of mankind as a whole’, with particular emphasis on the developing countries that lack the technology and capital to carry out seabed mining for themselves.

The International Seabed Authority develops internationally legally binding regulations. So far, it has issued regulations governing exploration for nodules, crusts and seabed massive sulfide deposits. The exploitation regulations are now being developed. The International Seabed Authority is using an innovative international consultation process to assist it in the development of these regulations. The mineral resources of the Area are

the common heritage of mankind, and the International Seabed Authority is consulting mankind on how these resources are to be exploited and how the proceeds are to be allocated. All the responses to International Seabed Authority consultations are available on the International Seabed Authority's website. Pursuant to LOSC Articles 208 and 209, International Seabed Authority regulations also operate to set minimum environmental standards for national regulation of deep-sea mining on the "legal" continental shelf (i.e. within the Exclusive Economic Zone) and on the outer continental shelf where, and to the extent that, this portion of the shelf has been formally allotted to the coastal state by the Commission on the Limits of the Outer Shelf pursuant to a claim from that coastal state. The International Seabed Authority environmental regulations are already extensive (see the International Seabed Authority's website). No exploitation contracts have yet been applied for.

The International Seabed Authority sponsors research, workshops and publications. The results are freely available on the International Seabed Authority's website and associated apps. Much of this technical activity is channelled through the International Seabed Authority's Legal and Technical Commission. Composed of 30 scientific, technical and legal specialists, it has a heavy workload. For example, the Legal and Technical Commission reviews draft regulations, examines and recommends actions by the Council of the International Seabed Authority on applications for work in the Area, monitors and comments on the contractors' work in the Area through the latter's required annual reports, and deals with the implementation of the extensive marine environmental protection duties imposed by the Law of the Sea Convention for deep-sea mining activities.

### ***The International Seabed Authority's Environmental Data Requirements***

The International Seabed Authority's environmental data requirements are extensive, as can be expected from the Law of the Sea Convention's own requirements and the environmental challenges set out in TABLE 1. All relevant data – including oceanographic, hydrographic, geological, chemical and biological data, data standards and inventories, cruise reports, and raw environmental data – must be published in the format established by the International Seabed Authority and all data must be made freely available for scientific analysis within four years after completion of a research cruise. An inventory of the data holdings from each contractor must be accessible on the World Wide Web. Metadata describing analytical techniques, error analyses, descriptions of failures, techniques and technologies to avoid, comments on sufficiency of data, and other relevant descriptors must be included with the actual data. To answer questions on the environmental impacts of mining, specific experiments, observations and measurements must be conducted. In this context, the Law of the Sea Convention and the International Seabed Authority strongly encourage collaborative research by contractors in which the International Seabed Authority also endeavours to participate when possible. Not all contractors are required to execute the same studies, and the International Seabed Authority encourages, advises, and assists in identifying cooperative research opportunities between contractors and other research communities. Such collaborative research is needed in, for example, the following instances:

- To minimize, and possibly mitigate, the effects of the loss of hard substrate (e.g. in the Clarion–Clipperton Zone for nodules);

- To develop methods to minimize the effects of the direct disturbance of the seafloor during mining, and of the material carried in, and deposited from, the operational plume generated;
- To enhance natural recolonization of the seabed after mining has taken place.

This requires detailed, long-term (at least ten years) regional and local baseline and operational research, including experiments and modelling. Even ten years may be insufficient time to fully understand the impacts of deep-sea mining: in the deep sea, disturbed biological communities rebuild only very slowly (Jones et al. 2018 this issue). The major challenges are to first minimize and then, if possible, mitigate and remediate the effects of mining with regard to, in particular, hard substrate removal and sedimentation.

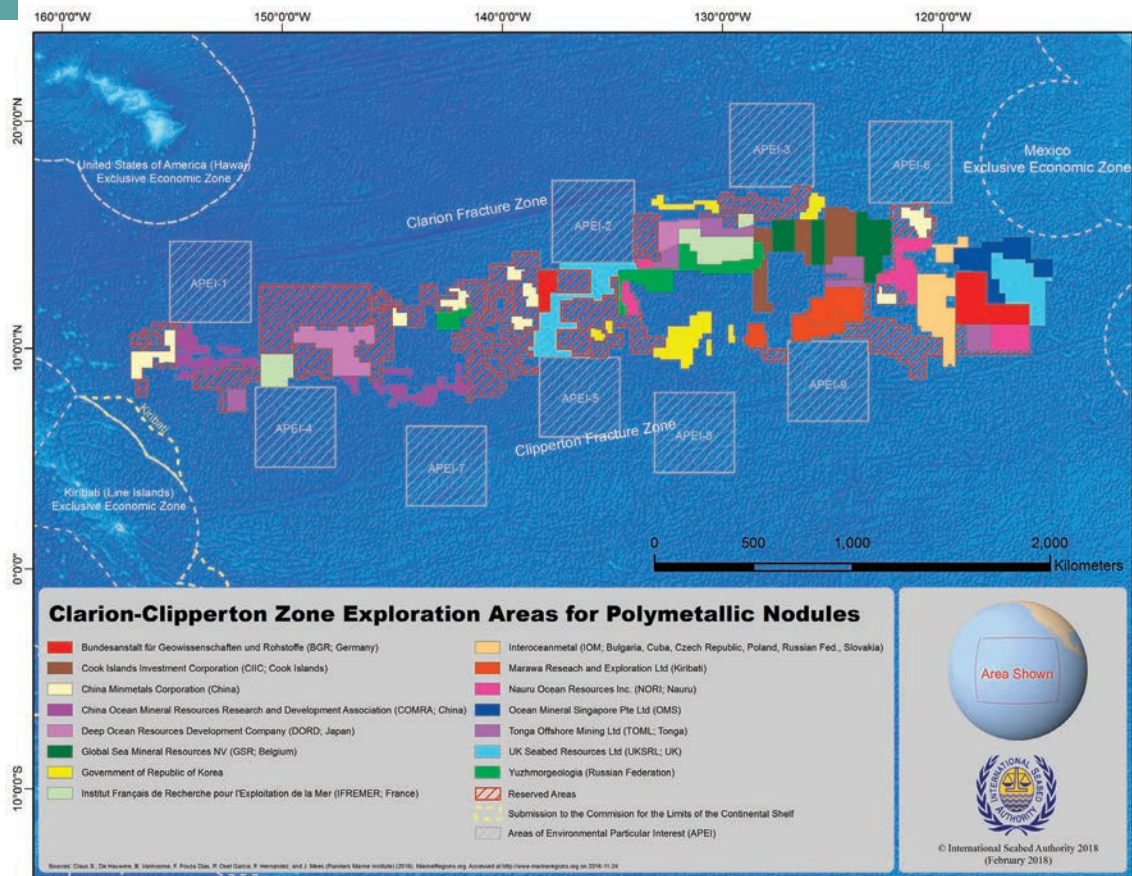
### ***Environmental Regulatory Challenges***

The International Seabed Authority needs all this environmental information because it must also engage in regional environmental management, which includes assessment and management of cumulative and local impacts of mining activities, biodiversity conservation, and facilitation of benthic recolonization. For an area the size of, for example, the Clarion–Clipperton Zone (~7 million km<sup>2</sup>) in the northeast Pacific Ocean, and with (as of 1 February 2018) 16 different exploration contracts from 18 different state parties, this is a daunting challenge (FIG. 2). Nevertheless, the Clarion–Clipperton Zone is the area where these requirements are going to be first set out and tested. This is because the Clarion–Clipperton Zone is the only region in the deep sea that has been subject to ongoing research in all the oceanographic and many of the engineering disciplines since the 1960s, and because its nodules are the closest to exploitation of the three categories of resources located in the Area. All 18 state parties have exploration contracts for nodules in the Clarion–Clipperton Zone.

## **REFLECTIONS ON THE REGULATORY CHALLENGES FACING THE INTERNATIONAL SEABED AUTHORITY**

Seafloor minerals are the only example of a global resource that is under international contractual management by an international organization established exclusively for that purpose. This immediately distinguishes them from other resources in frontier environments, such as those in outer space. Therefore, the International Seabed Authority represents a unique experiment in international law, international relations, and international regulatory development. For many countries, it fulfils a long-held vision that the mineral wealth of the deep seabed beyond national jurisdiction should not be appropriated by a few technologically advanced countries but should be shared between all countries, including the landlocked and disadvantaged countries, given its status under the Law of the Sea Convention as the common heritage of mankind. The task of the International Seabed Authority is to deliver on this vision and to make sure that it is done in the most responsible and sustainable way possible.

Two major challenges confront the International Seabed Authority at present. The first is to establish a workable regulatory framework for mineral exploitation that incentivizes contractors to commit significant investment and resources to develop deep-sea mining projects, but which also addresses concerns of state parties to the Law of the Sea Convention, as well as other stakeholders, such as environmental groups. These concerns range around, for example, regulatory stability and predictability, and the financial and environmental management regime.



**FIGURE 2** The Clarion–Clipperton Fracture Zone in the northeast Equatorial Pacific Ocean. Each coloured block represents an area under current exploration for polymetallic nodules by various contractors. The associated sponsoring states are indicated

in brackets. The map also shows Areas of Particular Environmental Interest as squares with diagonal white lines. IMAGE: INTERNATIONAL SEABED AUTHORITY.

The second major challenge is environmental planning at the regional scale. As briefly described above, this is a greater, and potentially far more interesting, challenge. If project-based environmental management is primarily the function of the operator, the other major task of the International Seabed Authority is to manage it at a global and regional scale. In one critically important way, this is already the case, because the fundamental concept of the Law of the Sea Convention is that deep seabed mining is only allowed to take place under contract to the International Seabed Authority. Hence, the default position is that the seabed is off limits to mining except where expressly permitted by the International Seabed Authority following a lengthy process of approval. Everything is protected. This essential aspect immediately sets deep seabed mining apart from any other high-seas activity, including fishing. But more work is needed to effectively manage environmental planning at a regional scale.

With regard to deep seabed mining and the environment, a major challenge is addressing the persistent unease that deep seabed mining must be bad for the marine environment in some way. This unease may be in part attributable to the word ‘mining’, which conjures up images of destruction taken from controversial practices ascribed to some land-based operations. When this is juxtaposed with the popular – but alas erroneous – image of the deep seabed as a pristine wilderness, then alarm does result. In reality, seabed mining has been around for centuries. It is likely that the deep seabed mining industry will use or adapt many of the proven technologies and management techniques used successfully for many years in shallow-water mining.

As alluded to above, there is good evidence that, compared to land-based mining, seabed mining offers a more commercially and environmentally sustainable source of raw material supply far into the future. Therefore, dramatic headlines such as ‘an invisible land grab’, ‘machines the size of buildings literally destroying the systems that keep us alive’, ‘clear-cutting the ocean floor’, and so forth, are misleading, emotive and not constructive. Similarly, comparisons to disasters such as the oil spill from the *Deepwater Horizon* in the Gulf of Mexico in 2010, which involved a volatile compound totally different in character to deep-sea hard-mineral ores, are misguided.

It is necessary that, collectively, the international community ground its regulatory discussions in reality. Key points are set out in the paragraphs immediately below.

Deep seabed mining has not started yet. All activities to date are exploration, which so far have involved no significant environmental impact. Therefore, the international community has a unique opportunity to get it right. In fact, this is probably the best-regulated industry that has not happened yet!

Even when deep seabed mining does start, it will most likely be at the scale of a limited number of operations. Based on the size of investments required, no one is currently predicting more than a handful of commercial operations during the first 15 or so years. This offers ample time to monitor and assess impacts, learn from experience and to improve technology.

Existing, well-established and proven environmental management techniques are easily applicable to deep seabed mining. The international community agrees that environmental impact assessments are required and that

the regulator must specify the level of permitted impacts. The standard environmental management tools that have been used in offshore industries for years – spatial management, impact assessment, prevention, and mitigation – are all applicable.

Worst-case scenarios are massively exaggerated and bear very little relation to reality. By and large, deep-sea mining involves rocks and mud, not volatile compounds under pressure. No tailings (in the land-based mining sense) result from deep seabed mining, operations can be monitored and halted very quickly, and direct impacts stopped rapidly.

It is clearly acknowledged that the international community, in the form of the International Seabed Authority, is embarking upon a new adventure, with many unknown factors to consider, and that it is confronted with real problems around a lack of detailed knowledge of deep-sea ecosystems, a lack of scientific data, and an uncertainty as to the scale and duration of impacts.

It must be stressed, however, that it is useless and counter-productive to argue that an a priori condition for deep-sea mining is an existential debate about whether it should be permitted to go ahead or not. The international community passed that point already many years ago. This is because the one factor that distinguishes deep seabed mining from any other extractive activity, or indeed any other ocean use, is the nature of the underlying legal regime established by the Law of the Sea Convention, as briefly described above.

Nevertheless, it is clear that it will be necessary to drastically improve our knowledge of the deep seabed, both inside and outside of exploration areas. This is, in fact, being done through systematic and regulated exploration, to the overall benefit of all of us. Another critical and urgent step is to design representative networks of protected areas, managed by the International Seabed Authority, where no mining should occur. So far, the only regional environmental management plan is that for the Clarion–Clipperton Zone adopted in 2012. This ground-breaking and unique plan originated in work funded by the J. M. Kaplan Fund (a New York-based foundation for social and environmental causes) and the Pew Charitable Trusts (a Philadelphia-based organization that applies research to improve aspects of public life) to develop a scientific case for identifying a biogeographically representative network of potential protected areas. The plan was subsequently developed through an expert consultative process under the auspices of the International Seabed Authority and adopted by its political organs.

The main feature of the plan is nine Areas of Particular Environmental Interest (Fig. 2). But this also highlights one of the main flaws of the plan. It is of limited value to just set aside protected areas on the basis of models. Actual data are required to obtain a better overall picture of the regional environment. The amount and quality of available data have improved tremendously over the past few years as contractors have advanced their exploration programmes and as international scientific investigations

have been undertaken. Several contractors have cooperated with the International Seabed Authority to gather data on the Areas of Particular Environmental Interest. A high priority are independent scientific research cruises, preferably with the participation of the International Seabed Authority and of developing-country scientists and specifically aimed at gathering data on the Areas of Particular Environmental Interest and surrounding areas. Only then can the International Seabed Authority undertake a meaningful review of the Clarion–Clipperton Zone Regional Environmental Management Plan and make decisions for the future.

Beyond the Clarion–Clipperton Zone, singled out here as the part of the Area most likely to see deep-sea mining occur first, both the International Seabed Authority Council and the General Assembly of the United Nations recognize the urgent need to develop regional plans in other mineral provinces of the Area where exploration activities are taking place. Member states of the International Seabed Authority emphasize the need for a global, multi-regional approach that would enable the production of better policy and operational frameworks for site-specific management activities. Key areas for consideration include the Mid-Atlantic Ridge, the Central Indian Ocean Triple Junction, and the northwest Pacific Ocean.

Regional environmental plans, designed to collate all relevant scientific data for each sub-region of the Area, are the best way to complement the work already undertaken by the International Seabed Authority and to give more ownership to state parties in each region, particularly developing countries. In turn, this would strongly contribute to the discussions held within the International Seabed Authority for developing the necessary frameworks and processes in order to set specific management objectives for contractors in the planning and monitoring of exploration and mining activities, particularly where multiple activities are taking place in the same maritime zone. The challenge is that scientific work on the required scale is very expensive. Even more resources are required to carry out long-term monitoring to measure and understand changes to the environment over time.

## CONCLUSION

The International Seabed Authority has a unique, legally mandated opportunity to establish a comprehensive framework for commercially and environmentally responsible management of the emerging deep-sea mining industry. It hopes that others will find this vision equally compelling and will join it in this endeavour.

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## REFERENCES

Freestone DF (2011) Advisory opinion of the Seabed Disputes Chamber of international tribunal for the law of the sea on “Advisory opinion on responsibilities and obligations of states sponsoring persons and entities with respect to activities in the area”. American Society of International Law Insights 15, available at <https://www.asil.org/insights/volume/15/issue/7/advisory-opinion-seabed->

[disputes-chamber-international-tribunal-law-sea-](https://www.asil.org/insights/volume/15/issue/7/advisory-opinion-seabed-disputes-chamber-international-tribunal-law-sea-)

Jones DOB, Amon DJ, Chapman ASA (2018) Mining deep-ocean mineral deposits: what are the ecological risks? Elements 14: 325-330

Koh TTB (1983) A Constitution for the Oceans. Remarks by Tommy T. B. Koh of Singapore, President of the Third United Nations Conference on the Law of the Sea. In: United Nations Convention on the Law of the Sea,

with Index and Final Act of the Third United Nations Conference on the Law of the Sea. United Nations Publication No. E.83.V.5, New York, NY, pp. xxxiii-xxxvii

ITLOS (2011) Responsibilities and Obligations of States Sponsoring Persons and Entities with Respect to Activities in the Area: Advisory Opinion. Seabed Disputes Chamber of the International Tribunal for the Law of the Sea, 75 pp ■