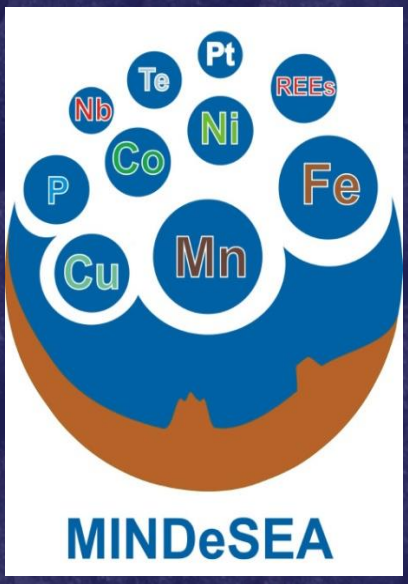
MINDeSEA

Seabed Mineral Deposits in European Seas: Metallogeny and Geological Potential for Strategic and Critical Raw Materials



Deliverable 4.6: Literature review report on present-day status of regulation, legislation and exploitation of ferromanganese crusts and phosphorites, with emphasis on the impact of a pan-European research approach

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D4.6. Literature review report on present-day status of regulation, legislation and exploitation of ferromanganese crusts and phosphorites, with emphasis on the impact of a pan-European research approach

Summary:

GeoERA is a Co-Fund ERA-NET action under Horizon 2020, towards "Establishing the European Geological Surveys Research Area to deliver a Geological Service for Europe". Its main objective is to contribute to the optimal use and management of the subsurface.

The project "Seabed Mineral Deposits in European Seas: Metallogeny and Geological Potential for Strategic and Critical Raw Materials" (MINDeSEA), materialized in the frame of the GeoERA Raw Materials Theme (Grant Agreement Nº 731166, project GeoE.171.001), resulted from the collaboration between eight GeoERA Partners and four Non-funded Organizations at various points of common interest for exploration and investigation on seafloor mineral deposits.This report analyses the dissemination and exploitation activities carried out throughout the project by all partners involved in the project.

This document reports and summaries the present status of seabed mining with special emphasis on ferromanganese crusts and phosphorites, considering also polymetallic nodules and hydrothermal sulphides as major resources in high seas. A selection of regulations, legislations, reports and publications on seabed mining in the European and international framework are presented and analysed. The document aims firstly to the status of exploration and exploitation of mineral resources in international waters beyond the national jurisdictions, under the International Seabed Authority rules. National regulations on seabed mining and study of cases in European and oceanic countries are presented in the second part of the document. Finally, the report is focused on the present day seabed mining operations, their technological- and environmental-related issues including their research approach.

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1. Introduction

The rules and principles of the United Nations Convention on the Law of the Sea (UNCLOS) and the 1994 Implementation Agreement are developed in the "Mining Code" as the set of rules, regulations and procedures issued by the International Seabed Authority (ISA) to regulate the prospection, exploration and exploitation of deep sea mineral resources (ISA, 2021).

Beyond the boundaries of the national jurisdiction, which extends up to 200 miles from the coastline, the seabed and subsoil have been referred to as "the Area" (Willaert, 2019) (**Fig. 1**). According to article 76, the coastal State may establish the outer limits of its juridical continental shelf wherever the continental margin extends beyond 200 nautical miles by establishing the foot of the continental slope, by meeting the requirements of article 76, paragraphs 4 - 7, of the Convention. The resources found in the Area are qualified as the "common heritage of mankind" and are not subject to appropriation (UNCLOS, 1982-Art.136:137). Thus, any country could claim an extent area of the seabed and this is managed by a complex set of rules, which determine who can exploit these natural resources and under which conditions. This regime is formed by Part XI and some annexes of the UNCLOS and detailed regulations of the ISA.

The ISA is an autonomous international organisation established in 1994 under UNCLOS and the subsequent Agreement relating to Part XI of UNCLOS (1994 Agreement). The ISA enables UNCLOS members to carry out and control activities in the Area assigned to them. In addition, the ISA has to manage the benefits obtained from deep sea mining for humankind's benefit. UNCLOS establishes that natural resources in or on the seabed may only be exploited according to the rules established by international law (UNCLOS, 1982-Art.137). States, commercial entities and natural people may apply to the ISA to carry out exploration and exploitation activities in the Area. All mineral exploration and exploitation activities must be sponsored by a UNCLOS State Party and approved by the ISA.

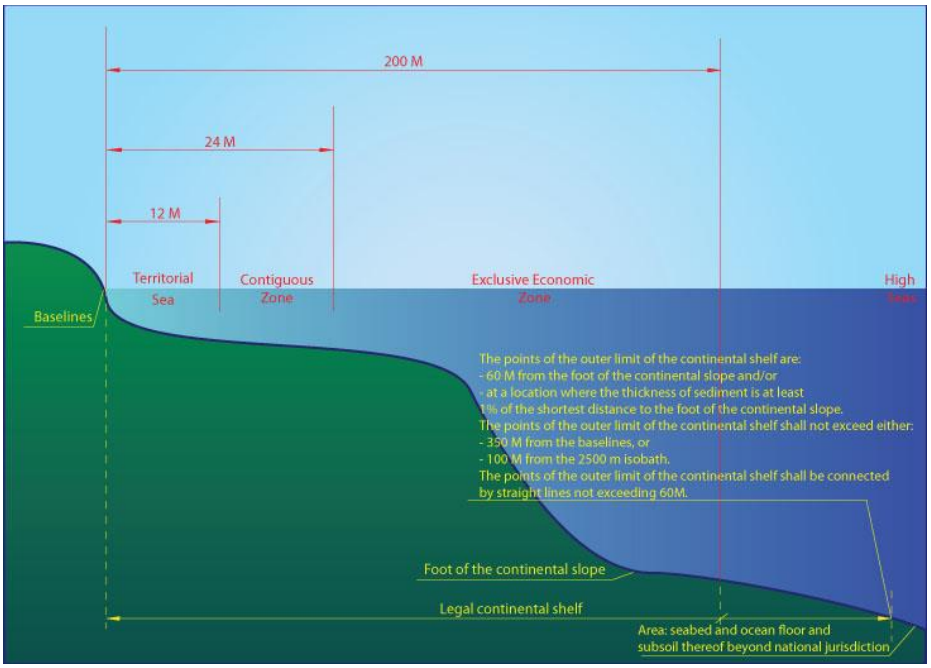

Figure 1. The legal context of management of the world's seas for the UNCLOS Member States. Modified from CLCS.

The ISA, among other tasks, is responsible for:

1- Require all the UNCLOS members to protect the marine environment from harmful effects that may arise from mining-related activities. For this, ISA should adopt appropriate rules, regulations and procedures for (UNCLOS, 1982-Art.145):

- The prevention, reduction and control of pollution and other marine environment hazards.
- The natural resource protection and conservation in the Area and the prevention of damage to flora and fauna in the marine environment.

UNCLOS, in Part XII, requires that national regulations on pollution caused by seabed activities in the Area and within national jurisdiction should be no less effective than recommended international rules, standards, practices, and procedures (UNCLOS, 1982-Art.208:209). In addition, all states have a shared obligation to protect and preserve the marine environment, including rare or fragile ecosystems, as well as the habitat of depleted, threatened or endangered species and other forms of marine life (UNCLOS, 1982-Art.82).

2. ISA: Regulations on Prospecting and Exploration for mineral resources in the Area and related matters

Summary

Regarding the exploration and exploitation of mineral resources in the Area, the ISA has distinguished between three classes: polymetallic nodules, polymetallic sulphides and cobalt-rich ferromanganese crusts. The ISA has created unique exploration regulations for each of them, to which contractors must adhere, and which lay out all of the laws and procedures necessary to develop exploratory activities. The polymetallic nodule regulation was the first to be issued in 2000, followed by the polymetallic sulphide regulation in 2010, and lastly, the in 2012 the ferromanganese crust regulation. Although the three regulations are founded on the same ideas, they differ somewhat in terms of the contractor's work area and the contractor's fees.

The names of the regulations are The Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area, Regulations on Prospecting and Exploration for Cobalt-rich Ferromanganese Crusts regulations on prospecting and exploration for polymetallic sulphides in the Area. Due to the similarities between the three regulations, they will henceforth be considered as one single document.

The regulation is complexly constructed. It is organized into nine thematic aspects, each of which is subdivided into separate sections. The first section of the document discusses the prospections that will be conducted in the Area, as well as the applications for approval of work plans for exploration. Following that are details on exploration contracts as well as the protection and preservation of the marine environment. Finally, it addresses confidentiality, general procedures, and project evaluation. Furthermore, four annexes include templates for the standard documents sought from the contractor, the exploratory contract, and the contract clauses. The annexes detail the information that the ISA requires from the contractor in order to execute an exploration contract. When submitting an application, the applicant must present his or her information pertaining to the selected zone, financial and technical information, the work plan to be followed, and the contractor's obligations in relation to the Area.

Application for an exploration contract

An application for a plan of work for exploration must be submitted by a State member of UNCLOS, a state enterprise, or a private company with member State support by submitting the required documentation by the regulations to explore the ISA (ISBA/19/C/17-Art.9; ISBA/19/C/17-Art.10; ISBA/18/A/11-Art.9; ISBA/18/A/11-Art.10; ISBA/16/A/12/Rev.1-Art.9; ISBA/16/A/12/Rev.1-Art.10) paying an amount of money at the time of application. If the contractor wants to explore Polymetallic Nodules or Ferromanganese Crust, it must pay a fixed fee of 500,000 United States dollars at the time of applying (ISBA/19/C/17-Art.19; ISBA/18/A/11-Art.21). Whereas, if the contractor wants to explore Polymetallic Sulphides can choose between paying 500,000 United States dollars at the time of submitting an application or a fixed fee of 50,000 United States dollars at the time of submitting an application and an annual fee calculated with the age of the contract and the number of square kilometres comprised in the exploration area (ISBA/16/A/12/Rev.1-Art.21). Each application submitted by a State enterprise or one of the entities referred to the regulation shall be accompanied by a certificate of sponsorship issued by the State of which it is a national or by which or by whose nationals it is effectively controlled. Suppose the applicant has more than one nationality, as in the case of a partnership or consortium of entities from more than one State. In that case, each State involved shall issue a certificate of sponsorship. If the applicant has the nationality of one State but is under the control of another State, each State shall issue a certificate of sponsorship (ISBA/19/C/17-Art.11; ISBA/18/A/11-Art.11; ISBA/16/A/12/Rev.1-Art.11). The contractor must have this sponsorship for the entire duration of the contract. In the event of termination of sponsorship, the contractor shall obtain another sponsor within the next six months; otherwise, the contract will be dissolved (ISBA/19/C/17-Art.29; ISBA/18/A/11-Art.31; ISBA/16/A/12/Rev.1-Art.31).

The application must define the boundaries of the requested Area by a list of coordinates. There are apparent differences for each of the resources in this aspect. The basis for the three regulations is the same. According to the rules, the total area allocated to the contractor under the contract shall not exceed a determined size and the contractor shall progressively relinquish portions of the Area. The regulation for polymetallic nodules says that the total Area allocated to the contractor must be less than 150,000 km^2 and after eight years, it must have relinquished the 50% of it (ISBA/19/C/17-Art.25). In the case of the Ferromanganese Crust, the Area allocated is less than 3000 km^2 divided in a maximum of 150 blocks no greater than 20 km^2 (ISBA/18/A/11-Art.27). After ten years, the contractor shall have relinquished at least 2/3 of the original Area. Referring to Polymetallic Sulphides the total Area allocated must be less than 10,000 km^2 and after ten years, the size of the Area shall be reduced a 75% or not less than 2500 km^2 (ISBA/16/A/12/Rev.1-Art.27). A work plan for exploration shall be approved for a period of fifteen years. Upon expiration the contractor shall apply for an exploitation or an extension for the plan of work for exploration. If the exploration contract is finished, not later than six months before the contractor may apply for extensions for periods of not more than five years each (ISBA/19/C/1-Art.26; ISBA/18/A/11-Art.28; ISBA/16/A/12/Rev.1-Art.28).

2.1.1. Information required in the plan of work

Regulation 1 of the Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area defines the term 'exploration' as follows: "the searching for deposits of polymetallic nodules in the Area with exclusive rights, the analysis of such deposits, the use and testing of recovery systems and equipment, processing facilities and transportation systems and the carrying out of studies of the environmental, technical, economic, commercial and other appropriate factors that must be taken into account in exploitation" (ISBA/19/C/17-Art.1; ISBA/18/A/11-Art.1; ISBA/16/A/12/Rev.1-Art.1). Accordingly, obtaining an exploration contract by a contractor grants exclusive rights to exploration and possible future exploitation of the mineral resources in that Area. To

obtain such a contract is necessary to submit a plan of work for exploration to the ISA. The Commission will examine the application and submit to the Council a report and recommendations on the designation of the areas and the plan of work for exploration (ISBA/19/C/17-Art.21; ISBA/18/A/11-Art.23; ISBA/16/A/12/Rev.1-Art.23). If the plan of work meets the requirements of the regulations, it is submitted to the Council for their approval, and the contract and its terms will be formalised (ISBA/19/C/17-Art.22; ISBA/18/A/11-Art.24; ISBA/16/A/12/Rev.1-Art.24; ISBA/19/C/17-Art.23; ISBA/18/A/11-Art.25; ISBA/16/A/12/Rev.1-Art.25).

Regarding the information to be included in the plan of work for exploration, the ISA requires contractors to submit the following information (ISBA/19/C/17-Art.18; ISBA/18/A/11-Art.20; ISBA/16/A/12/Rev.1-Art.20):

- A basic description and timetable of the proposed exploration program, including the activities for the next five years, such as studies to be conducted on the environmental, technological, economic, and other relevant elements that must be considered in exploration;
- Description of the program for oceanographic and environmental baseline studies in accordance with these Regulations and any environmental rules, regulations, and procedures established by the ISA that would allow an assessment of the potential environmental impact of the proposed exploration activities, including, but not limited to, the impact on biodiversity, taking into account any recommendations;
- A preliminary assessment of the possible impact of the proposed exploration activities on the marine environment;
- A description of proposed measures for the prevention, reduction and control of pollution and other hazards, as well as possible impacts, to the marine environment;
- Financial data and a list of planned annual expenditure concerning the programme of activities for the immediate five-year period.

Concerning the protection and preservation of the marine environment during the exploration phase, the ISA requires the contractor to take all reasonable steps to prevent, reduce, and control pollution and other hazards to the marine environment arising from its activities in the Area, using a precautionary approach and best environmental practices as much as possible. As a result, before beginning exploration efforts, the contractor must submit:

- An impact assessment of the potential effects on the marine environment of the proposed activities;
- A proposal for a monitoring programme to determine the potential effect on the marine environment of the proposed activities; and
- Data could be used to establish an environmental baseline against which to assess the effect of the proposed activities.

In addition, the contractor shall obtain environmental baseline data as exploration activities progress and develop and shall establish environmental baselines against which to assess the likely effects of the contractor's activities on the marine environment. In addition to this, the contractor shall develop and carry out a programme to monitor and report such effects on the marine environment. These actions must be carried out in cooperation with the ISA and provide them with all necessary information (ISBA/19/C/17-Annex IV-5; ISBA/18/A/11- Annex IV-5; ISBA/16/A/12/Rev.1- Annex IV-5).

2.1.2. Annual reports

During the years of the exploration contract, the contractor must report periodically to the ISA through annual reports so that the ISA can verify that the activities being carried out correspond to what is established in the exploration plan and under regulations established by the ISA (ISBA/19/C/17-Annex IV-10; ISBA/18/A/11- Annex IV-10; ISBA/16/A/12/Rev.1- Annex IV-10). This report shall contain detailed information on:

- The exploration work carried out during the calendar year, including maps, charts and graphs illustrating the work that has been done and the results obtained;
- The equipment used to carry out the exploration work, including the results of tests conducted of proposed mining technologies, but not equipment design data; and
- The implementation of training programmes and other relevant information.

2.1.3. Data and information to be submitted on the expiration of the contract

Once the exploration contract is finished, the contractor shall transfer to the ISA all data and information necessary and relevant for the effective exercise of the powers and functions of the ISA in respect of the exploration area. For this purpose, he shall submit the following data and information (ISBA/19/C/17-Annex IV-11; ISBA/18/A/11- Annex IV-11; ISBA/16/A/12/Rev.1- Annex IV-11):

- Copies of geological, environmental, geochemical and geophysical data acquired by the contractor in the course of carrying out the programme of activities that are necessary for and relevant to the effective exercise of the powers and functions of the ISA in respect of the exploration area;
- The estimation of mineable areas, when such areas have been identified, which shall include details of the grade and quantity of the proven, probable and possible polymetallic nodule reserves and the anticipated mining conditions;
- Copies of geological, technical, financial and economic reports made by or for the contractor that are necessary for and relevant to the effective exercise of the powers and functions of the ISA in respect of the exploration area;
- Information in sufficient detail on the equipment used to carry out the exploration work, including the results of tests conducted of proposed mining technologies, but not equipment design data;
- A statement of the number of polymetallic nodules recovered as samples or for testing; and
- A statement on how and where samples are archived and their availability to the ISA.

3. Draft regulations on exploitation of mineral resources in the Area

The negotiation of Regulations on exploitation of mineral resources in the Area is in progress. As the reduced format of the 26th session of ISA, scheduled to take place on 6-10 December 2021, imposed by COVID-19 related protocols will not allow for the resumption of negotiations on the text of the Draft Regulation on Exploitation of Mineral Resources in the Area.

The Draft regulations on the exploitation of mineral resources in the Area are complex. It comprises an introductory part and thirteen thematic sections, which are subdivided into different sub-sections. The first chapters deal with the basic principles, the application procedure, the rights and duties of contractors, and the marine environment's protection. This is followed by the chapters concerning the financial terms of operating

contracts, the collection and processing of information, the development of standards and guidelines, the inspection and compliance system, and disputes settlement. The following chapters include ten annexes and four appendices. The annexes consist of standard templates and practical instructions detailing the content and structure of documents and plans submitted to the Authority. The appendices contain, in turn, a list of all events to be notified by the contractor, a schedule for the payment of annual fees and other applicable costs, a summary of possible financial penalties and a methodology for the fee calculation.

Rules and procedures

The Draft regulations on exploitation are based on the ISA regulations concerning exploration activities for Polymetallic Nodules, Cobalt-rich Ferromanganese Crusts and Polymetallic Sulphides and many requirements for submitting an exploitation contract are similar to the data required to get an exploration contract. During the years of the exploration contract (15 years extendable for another five years), the contractor has to gradually return parts of the exploration area to ISA. Thus, at the end of the exploration contract, the piece of Area available represents a fraction of the Area initially allocated to him. At this point, once the mining code is approved, exploitation activities will be developed (ISBA/19/C/17-Art.25).

In comparison with the exploration regulations, eligible applicants remain the same and the sponsorship requirement of a Member State is maintained, but the exploitation contracts have a duration of 30 years, extendable for a further ten years (ISBA/25/C/WP.1-Art.20). In addition to the application fee and annual fees (ISBA/25/C/WP.1-Appendix IV), these contracts require royalties based on a system of fees for the resources extracted (ISBA/25/C/WP.1-Art.84:87). The precautionary principle is reaffirmed, but greater emphasis is placed on scientific evidence and transparency of the data obtained (ISBA/25/C/WP.1-Art.44).

Before starting the exploitation activities, the contractor must deposit a so-called “Environmental Performance Guarantee” to the ISA to cover, among other things, the cost of monitoring the possible environmental impact after the cessation of the activities, without excluding the contractor’s responsibility (ISBA/25/C/WP.1-Art.26). In addition, the draft regulations on exploitation provide for the creation of an environmental compensation fund to prevent or repair possible damage in case of non-liability of the contractor or sponsoring country (ISBA/25/C/WP.1-Art.54:56). It will also serve to promote scientific research and training related to the protection of the marine environment. The funding required for this will be through the recovery of fees and sanctions imposed on contractors.

The submission and approval procedure required to carry out a work plan for exploitation is more thorough and complete than exploration. A contractor must submit the following documents to be able to apply for an exploration contract:

- Environmental Impact Statement (ISBA/25/C/WP.1- Art.47, Annex IV). This document should be the outcome of a series of studies that identify, predict and assess the effects of the proposed extractive operations, including a risk assessment, an impact analysis and a proposal for mitigation measures for the associated impacts.
- Environmental Management and Monitoring Plan (ISBA/25/C/WP.1-Art.48:52). A document that must confirm that the predicted environmental impact satisfies the standards established in the regulations. This document will be founded on the results of the environmental impact assessment and in keeping with the environmental management plans. Its function is to establish how mitigation measures will be implemented, how their effectiveness will be monitored and how adjustments to the measurements can be applied if necessary. During operation activities, the contractor shall provide environmental impact reports following this document,

which, together with the management plan report, are subject to performance reviews by the ISA. These will be done through public reporting.

- Closure Plan (ISBA/25/C/WP.1-Art.59). This document defines the contractor's responsibilities in monitoring the environmental impact after the end of the extraction activities. These documents will subsequently be published on the ISA website and all comments made by interested third parties will be submitted to the applicant, who has the chance to modify the plans (ISBA/25/C/WP.1-Art.7). As part of the comprehensive review of an application, the Legal and Technical Commission will examine these documents considering the comments made by third parties and possible responses from the applicant. It will consider whether the plans provide for adequate protection of the marine environment in accordance with Article 145 of the UNCLOS and the precautionary approach (ISBA/25/C/WP.1-Art.11).

The Legal and Technical Commission's report on the environmental plans, including any suggested changes or proposed amendments, will be republished on the website and the complete environmental dossier will be transferred to the Council. Suppose the Legal and Technical Commission considers that the plans discussed do not provide adequate protection for the marine environment. In that case, the applicant will be informed and allowed to rectify, followed by a further assessment by the Legal and Technical Commission (ISBA/25/C/WP.1-Art.15). The Council will make the final decision, but the same decision-making rules apply as for exploration contracts: a positive recommendation by the Legal and Technical Commission can be overturned by a two-thirds majority and a negative opinion does not necessarily prevent the approval of the plan of work by the Council (ISBA/25/C/WP.1-Art.16).

ISA Contractors

In the 70' - 80's many companies carried out large exploration expeditions in international waters and due to the great potential in mineral resources that they harboured, they claimed large extensions of the seabed under UNCLOS. This situation led to the creation of the ISA for the correct management of these resources.

By 2010, the ISA had only issued exploration contracts to eight different countries: France, Russia, Japan, China, Korea, Germany, a consortium of Eastern European countries and India. All of them for the exploration of polymetallic nodules. From this year onwards, interest in seabed mineral resources grew rapidly and in 2015, ISA had 25 exploration contracts for Nodules, Crusts and Sulphides. Today, 2021, ISA has issued a total of 31 exploration contracts: 19 for Nodules, 7 for Sulphides and 5 for Crusts. Nineteen of these contracts are for exploration of polymetallic nodules in the Clarion-Clipperton Fracture Zone (17), Central Indian Ocean Basin (1) and Western Pacific Ocean (1) (**Table 1**). There are four contracts for exploration for cobalt-rich crusts in the Western Pacific Ocean and one in the south Atlantic (**Table 2**). There are seven (7) contracts for exploration for polymetallic sulphides in the South West Indian Ridge, Central Indian Ridge and the Mid-Atlantic Ridge (**Table 3**).

Table 1. Polymetallic Nodule exploration Contracts issued by the ISA. There is more information by clicking on the "contractor" and "contract" boxes. Information given in the column called "Location" is referred to **Fig. 2**.

Polymetallic Nodules exploration contracts					
Contractor	**Contract Date**	**Expiration Date**	**Sponsoring State**	**Location**	**Contract**

Interoceanmetal Joint Organization	29/03/2001	28/03/2021	Bulgaria, Cuba, Czech Republic, Poland, Russian Federation and Slovakia	Zone 1	↗
JSC Yuzhmorgeologiya	29/03/2001	28/03/2021	Russian Federation	Zone 1	-
Government of the Republic of Korea	27/04/2001	26/042021	Korea	Zone 1	↗
China Ocean Mineral Resources Research and Development Association (COMRA)	22/05/2001	21/05/2021	China	Zone 1	↗
Deep Ocean Resources Development Co. Ltd.(DORD)	20/06/2001	19/06/2021	Japan	Zone 1	↗
Institut Français de recherche pour l'exploitation de la mer (IFREMER)	20/06/2001	19/06/2021	France	Zone 1	↗
Government of India	25/03/2002	24/03/2022	India	Zone 4	↗
Federal Institute for Geosciences and Natural Resources of Germany (BGR)	19/07/2006	18/07/2021	Germany	Zone 1	↗
Nauru Ocean Resources Inc. (NORI)	22/07/2011	21/07/2026	Nauru	Zone 1	↗
Tonga Offshore Mining Limited (TOML)	11/01/2012	10/01/2027	Tonga	Zone 1	↗
Global Sea Mineral Resources NV (GSR)	14/01/2013	13/01/2028	Belgium	Zone 1	↗
UK Seabed Resources Ltd. (UKSRL UK-I)	08/02/2013	07/02/2028	United Kingdom	Zone 1	↗
Marawa Research and Exploration Ltd.(MARAWA)	19/01/2015	18/01/2030	Kiribati	Zone 1	↗
Ocean Mineral Singapore Pte Ltd. (OMS)	22/01/2015	21/01/2030	Singapore	Zone 1	↗
UK Seabed Resources Ltd. (UKSRL UK-II)	29/03/2016	28/03/2031	United Kingdom	Zone 1	↗
Cook Islands Investment Corporation (CIIC)	15/07/2016	14/07/2031	Cook Island	Zone 1	↗
China Minmetals Corporation (CMC)	12/05/2017	11/05/2032	China	Zone 1	↗

Beijing Pioneer Hi-Tech Development Corporation (BPHDC)	18/10/2019	17/10/2034	China	Zone 6	-
Blue Minerals Jamaica Ltd. (BMJ)	04/04/2021	03/04/2036	Jamaica	Zone 1	-

Table 2. Cobalt-rich Ferromanganese Crusts exploration contracts issued by the ISA. There is more information by clicking on the "contractor" and "contract" boxes. Information given in the column called "Location" is referred to **Fig. 2**.

Cobalt-rich Ferromanganese Crusts exploration contracts					
Contractor	**Contract Date**	**Expiration Date**	**Sponsoring State**	**Location**	**Contract**
Japan Oil, Gas and Metals National Corporation (JOGMEC)	27/01/2014	26/01/2029	Japan	Zone 5	
China Ocean Mineral Resources Research and Development Association (COMRA)	29/04/2014	28/04/2029	China	Zone 5	
Ministry of Natural Resources and Environment of the Russian Federation (MNRE)	10/03/2015	09/03/2030	Russian Federation	Zone 5	-
Companhia De Pesquisa de Recursos Minerais (CPRM)	09/11/2015	08/11/2030	Brazil	Zone 3	
The Republic of Korea	27/03/2018	26/03/2033	Republic of Korea	Zone 5	

Table 3. Polymetallic Sulphides exploration contracts issued by the ISA. There is more information by clicking on the "contractor" and "contract" boxes. Information given in the column called "Location" is referred to **Fig. 2.**

Polymetallic Sulphides exploration contracts					
Contractor	**Contract Date**	**Expiration Date**	**Sponsoring State**	**Location**	**Contract**
China Ocean Mineral Resources Research and Development Association(COMRA)	18/11/2011	17/11/2026	China	Zone 4	
Government of the Russian Federation	29/10/2012	28/10/2027	Russian Federation	Zone 2	-
Government of the Republic of Korea	24/06/2014	23/06/2029	Republic of Korea	Zone 4	

Institut français de recherche pour l'exploitation de la mer (IFREMER)	18/11/2014	17/11/2029	France	Zone 2	
Federal Institute for Geosciences and Natural Resources of the Federal Republic of Germany (BGR)	06/05/2015	05/05/2030	Germany	Zone 4	
The Government of India	26/09/2016	25/09/2031	India	Zone 4	
Government of the Republic of Poland	12/02/2018	11/02/2033	Poland	Zone 2	

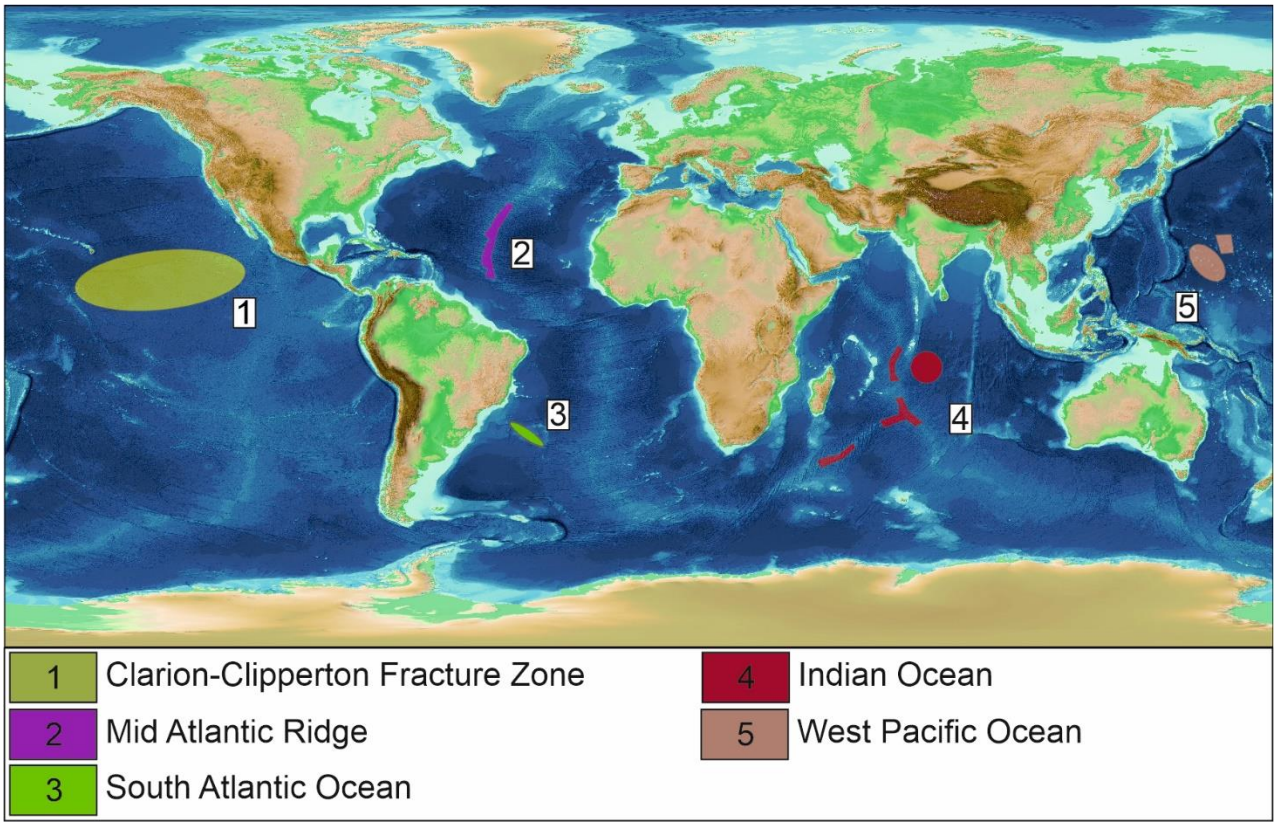

Figure 2. Main areas where the exploration areas of the exploration contracts awarded by ISA are located. Source: ISA (ISA) and GEBCO (GEBCO).

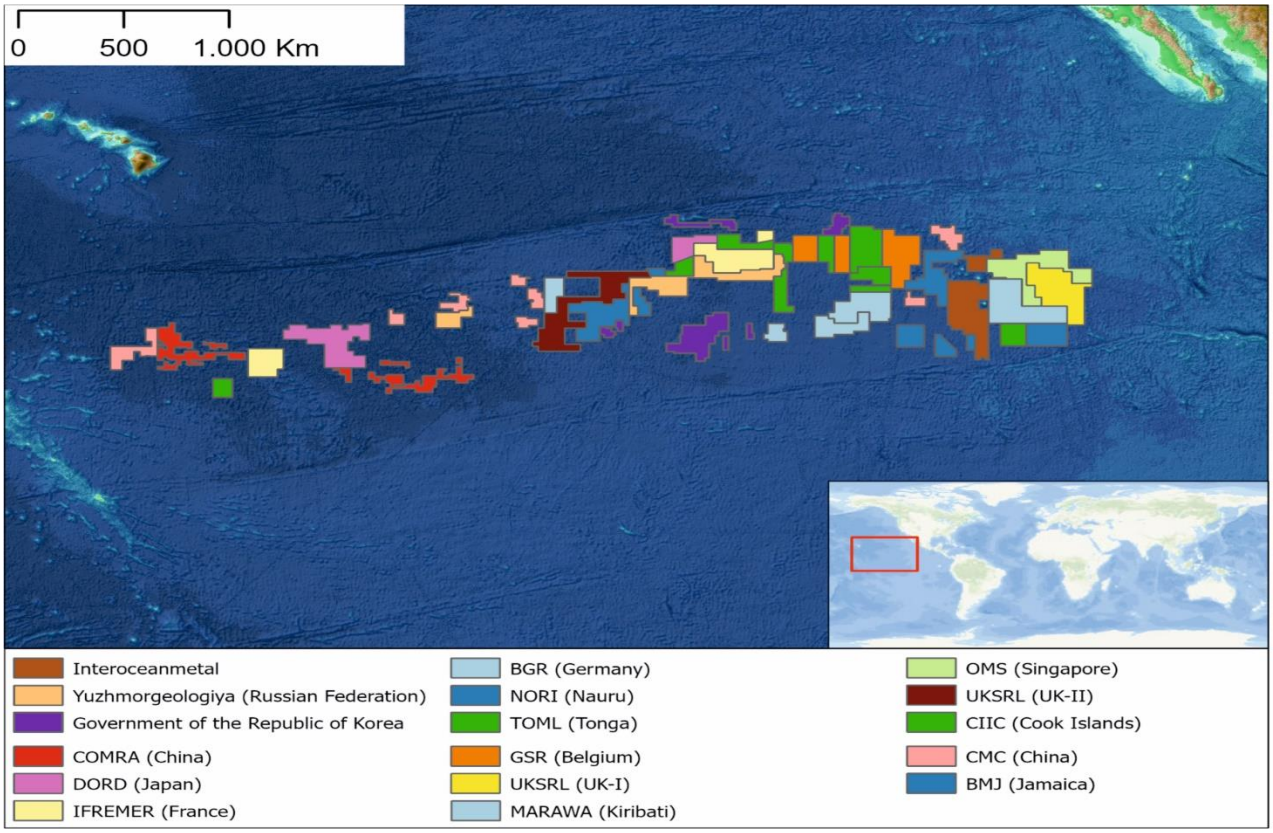

Figure 3. Areas allocated by ISA to contractors in the Clarion-Clipperton Zone (**Fig.2**, zone 1). All zones refer to Polymetallic Nodules. Source: ISA (ISA).

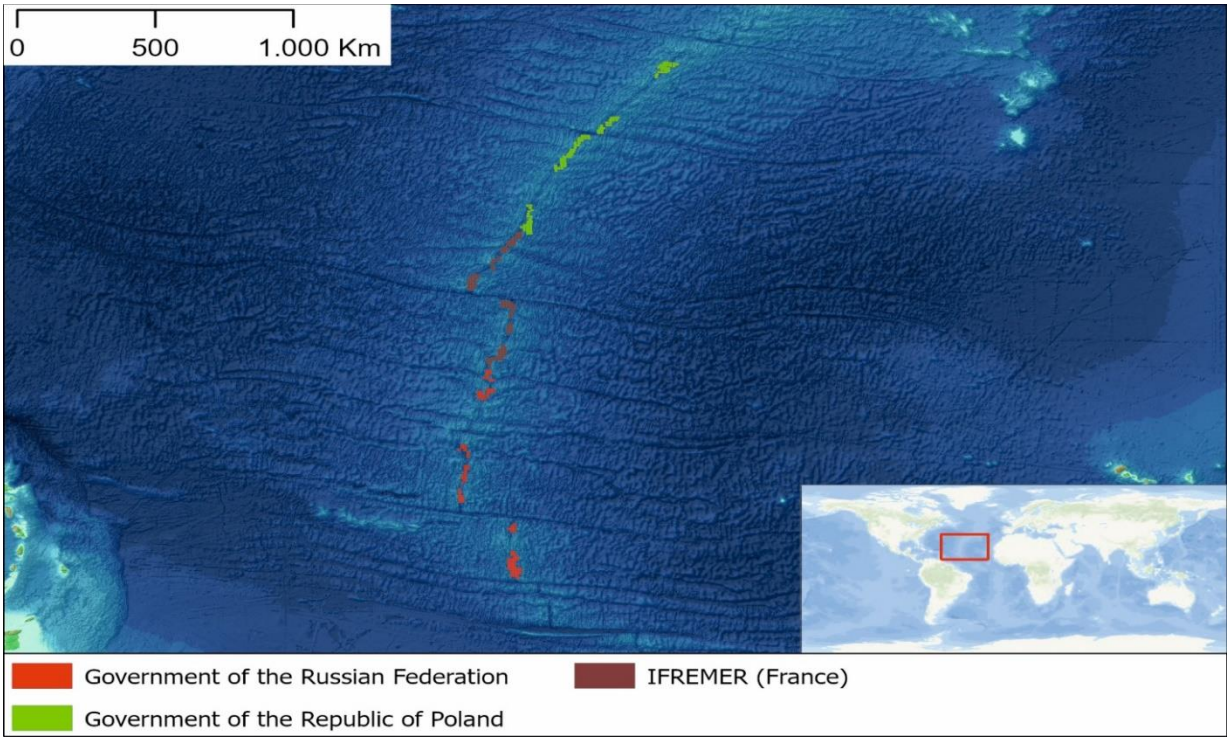

Figure 4. Areas allocated by ISA to contractors in the Mid Atlantic Ridge zone (**Fig.2**, zone 2). All zones refer to Polymetallic Sulphide. Source: ISA (ISA).

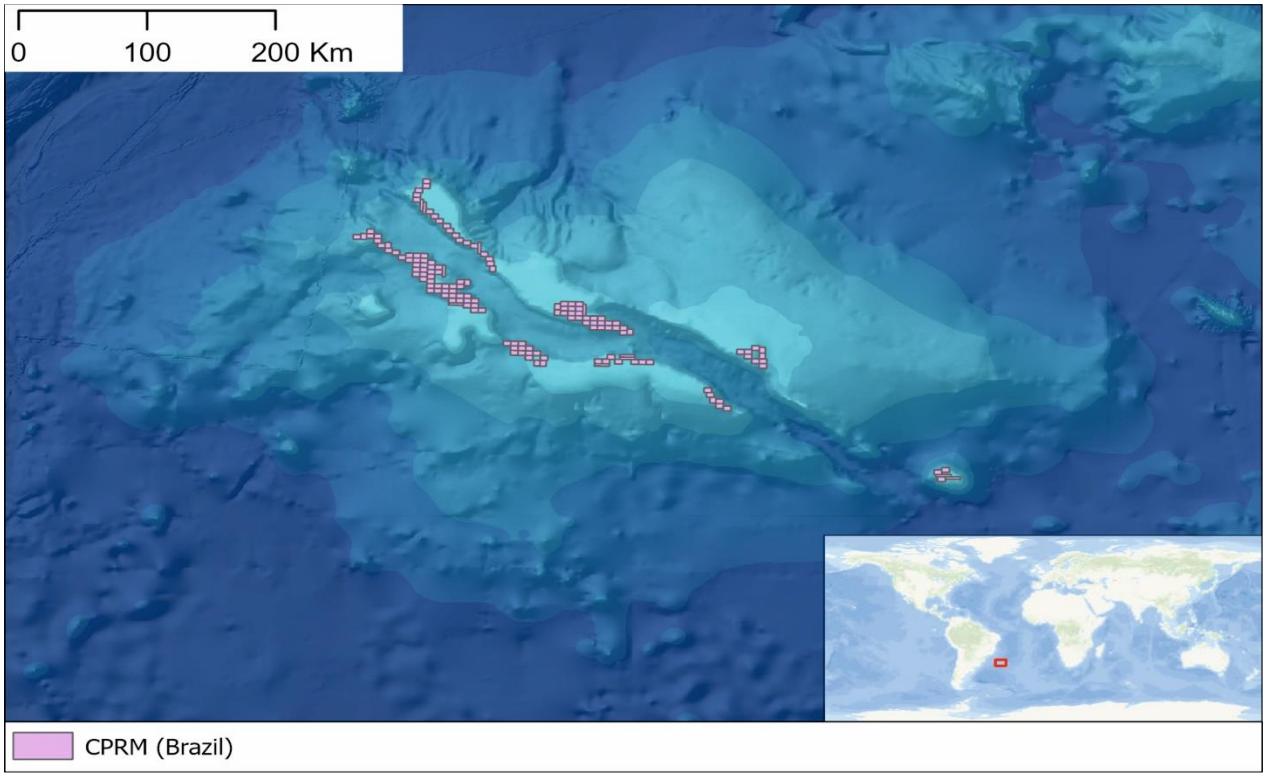

Figure 5. The Area allocated by ISA to the contractor in the South Atlantic Ocean (**Fig.2**, zone 3). All zones refer to Ferromanganese Crusts. Source: ISA (ISA).

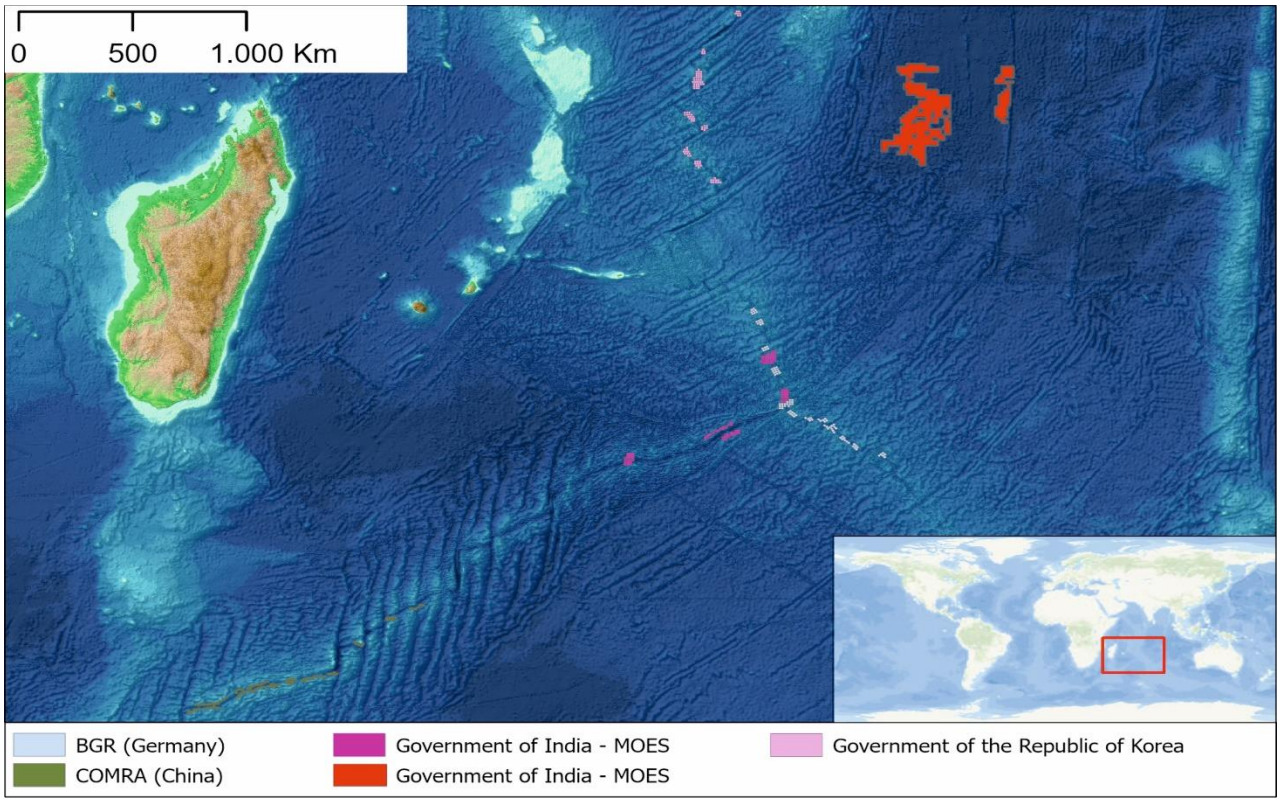

Figure 6. Areas allocated by ISA to contractors in the Indian Ocean (**Fig.2**, zone 4). All zones refer to Polymetallic Sulphide except two zones referred to Polymetallic Nodules (MOES, red). Source: ISA (ISA).

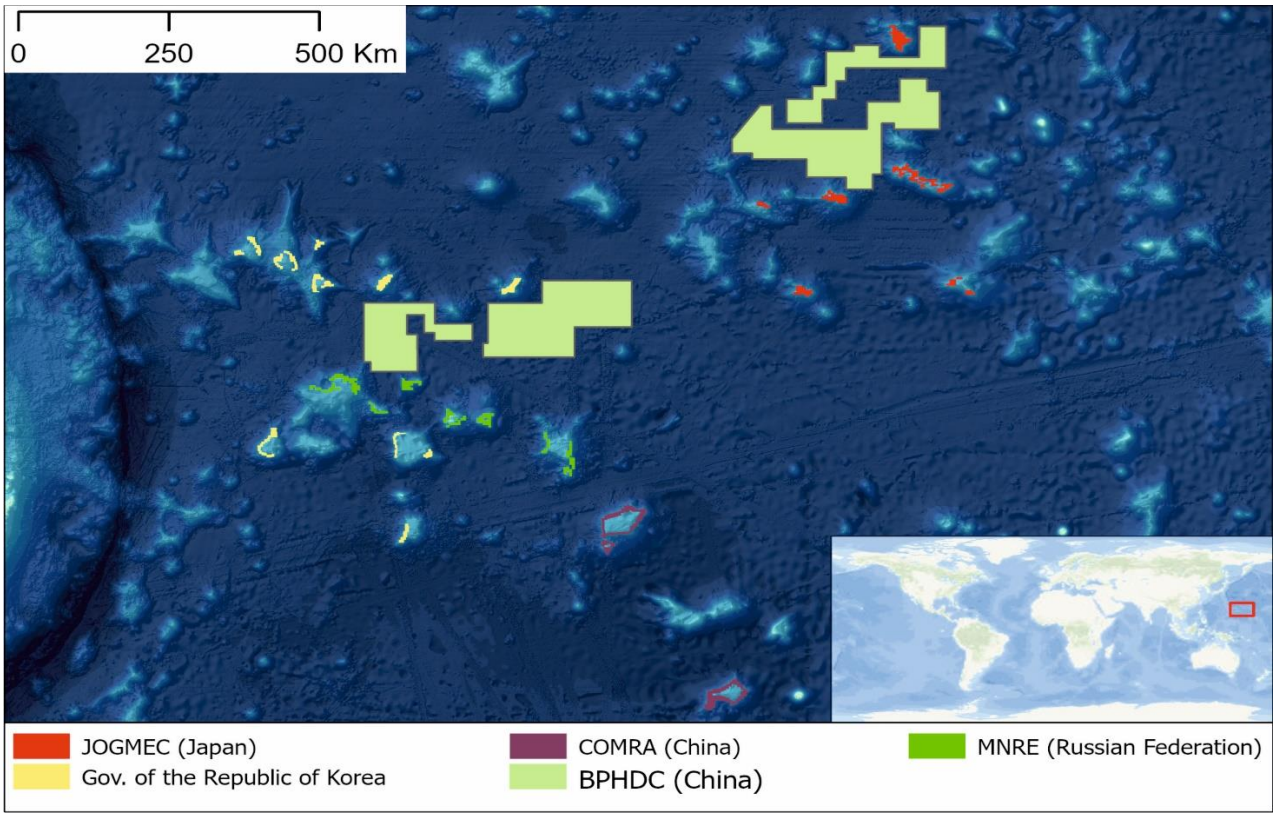

Figure 7. Areas allocated by ISA to contractors in the West Pacific Ocean zone (**Fig.2**, zone 5). All zones refer to Ferromanganese Crusts except four zones referred to as Polymetallic Nodules (BPHDC, light green). Source: ISA (ISA).

4. The national legislative framework for Deep Sea Mining

Regarding national legislation relating to deep sea mining, the application of various levels of legislation in different spatial and jurisdictional contexts must be highlighted.

Deep sea mining on the continental shelf of an EU Member State is regulated by the national legislation of the Member State under consideration, as well as by EU regulation, both of which are guided by international law (Case, 2006). Similar rules are applied to the Overseas Countries and Territories of EU Member States (OCTs). In the case of non-EU countries, EU legislation does not apply. However, some member states of the European Free Trade Association (namely Iceland, Liechtenstein and Norway) must apply elements of EU law in the context of the European Economic Area. lucSeabed mining activities on the country's continental shelf are developed under national legislation, guided or informed by international law. In other words, national legislation on deep sea mining must give effect to international law. Moreover, a coastal State is free to regulate, authorise or ban deep sea mining under its own environmental policies.

The ISA is responsible for implementing legislation on deep sea mining in waters beyond the EEZ and managing and controlling the area's activities. From a national legislation point of view, the countries sponsoring a contractor to develop exploration or exploitation activities in the Area should adopt appropriate measures to exercise control over any seabed mineral activities under its jurisdiction (Levin et al., 2020). As far as deep sea mining in the Area is concerned, the basic regime is established in international law in Part XI of UNCLOS and the

Part XI Implementation Agreement. However, the main subjects of international law are states and international organisations. One of the fundamental pillars of this legislation is Article 145 of UNCLOS, which establishes the general obligation of countries to protect the marine environment from the possible harmful effects of activiti es taking place in the Area. Under international law regarding seabed mining, direct duties include applying the precautionary approach, employing best environmental practices, and conducting prior environmental impact assessment (Freestone, 2011). In this context, many states have implemented national legislation that referred to deep sea mining exploration or exploitation activities both within national and international jurisdiction.

The legislative framework for the Area

Activities related to deep sea mining in the Area must be undertaken in the Area following the specific regime for deep sea mining established in UNCLOS, the Part XI Implementation Agreement and the Mining Code. However, such activities should also be carried out under the national legislation of the State sponsoring the person or entity engaged in deep sea mining.

Regarding legislation on deep sea mining in the Area, some EU Member States, France, Greece, Italy, the Netherlands, Portugal and Spain, do not have such legislation, although some of these countries are actively involved in ISA.

The ISA began developing an annual updated report containing the laws, rules, and administrative measures implemented by sponsoring states and other Authority members for activity in the Area in 2013 (ISBA/17/C/20-paragraph 3). According to the report, the following countries provided information to the Authority about relevant national legislation: Belgium, Brazil, China, Cook Islands, Cuba, Czechia, Dominican Republic, Fiji, France, Georgia, Germany, Guyana, India, Japan, Kiribati, Mexico, Montenegro, Nauru, Netherlands, New Zealand, Nigeria, Niue, Oman, Republic of Korea, Russian Federation, Singapore, Tonga, and Tuvalu. Pacific Community submissions had also been received (Comparative Study of the Existing National Legislation on Deep Seabed Mining, ISA 2018). Georgia and Guyana, on the other hand, do not have any national legislation governing the operations of the Area. National law filed by Cuba, India, Mexico, Montenegro, Nigeria, Niue, Oman, and Zambia addresses mining on land or within its national authority, maritime zones, and marine environmental protection without directly regulating operations in the Area. Brazil, Cuba, the Dominican Republic, the Netherlands, the Republic of Korea, and the Russian Federation are examining, revising, or implementing national laws governing operations in the Area. Cook Islands passed the Seabed Minerals Act 2009 in 2009, which was amended in 2015 by the Seabed Minerals Act 2015, and promulgated the Seabed Minerals (Prospecting and Exploration) Regulations 2015; these instruments govern the management of seabed minerals within the Cook Islands' national jurisdiction. The Cook Islands is currently revising the Seabed Minerals Act and Regulations (Comparative Study of the Existing National Legislation on Deep Seabed Mining, ISA 2018).Not all states have developed legislation with the same level of complexity and some of them still need much more development in many aspects like environmental protection.

Nine nations have implemented legislation in the form of an Act or Law that addresses the legal system for regulating activities in the Area (**Table 4**). Belgium, China, the Czech Republic, Germany, the Russian Federation, and the United Kingdom are among the European countries. Fiji, Japan, Nauru, New Zealand, and Singapore have established special legislation outside of Europe.

The German legislation is the Seabed Mining Act 1995, whereas the equivalent text in the United Kingdom is the Seabed Mining Act 2001. (**Table 4**). The present legislation in both nations either replaces earlier legislation (in Germany, the 1995 Act superseded and modified the preceding Interim Regulation on Seabed Mining 1980) or

has been updated by later legislation (the Seabed Mining Act substantially updated the Seabed Mining Act 2001). The old legislation in both cases was enacted in the early 1980s, prior to the ratification of UNCLOS, and the revised texts reflect the present legal framework for deep sea mining in the Area under international law. In the instance of France, it was integrated into an ordinance dealing to all marine regions under its authority or jurisdiction in general.

Kiribati, Tonga, and Tuvalu have one Act that governs seabed mining both inside their national jurisdiction and in the Area. Through their Acts or Laws, most states delegate regulatory authority to competent national agencies (China, Japan and Singapore). These laws are not as detailed and thorough as the ISA's Regulations on Prospecting and Exploration for Seabed Mineral Resources, but they cover the main important topics. These include the contractor's plan and goals, the licensing system for operations in the area, monitoring, supervision, and inspection, and marine environmental protection.

Table 4. ISA National Legislation Database collection of laws, regulations and administrative measures concerning activities in the Area based on some member states' submissions. Laws are available at Law-Database

Country	laws, regulations and administrative measures
Belgium	Act on prospecting and exploration for. and exploitation of resources of the seabed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction, adopted on 17 August 2013
China	Law of the People's Republic of China on Exploration for and Exploitation of Resources in the Deep Seabed Aiea. Adopted 26 February, 2016, and effective as of 1 May. 2016
Czech Republic	Act No. 158/2000 of 18 May, 2000, on Prospecting. Exploration for and Exploitation of Mineral Resources from the Seabed beyond the Limits of National Jurisdiction
France	Ordinance No. 2016-1687 of 8 December, 2016, relating to the maritime areas under the sovereignty or jurisdiction of the Republic of France
Fiji	International Seabed Mineral Management Decree (Decree No. 21, 12.07.2013).
Germany	Seabed Mining Act of 6 June 1995(Amended by article 74 of the Act of 8 December 2010)
Japan	Law on Interim Measures for Deep Seabed Mining. 1982
Kiribati	Seabed Minerals Act (2017)
Nauru	International Seabed Minerals Act (Act No. 26 of 2015)
New Zealand	United Nations Convention on the Law of the Sea Act (1996)
the Russian Federation	Decree of the President of 22 November 1994, No. 2099 "About activities of the Russian physical and legal entities for exploration and development of mineral resources of the seabed outside the continental shelf
	Government Decree of 25 April 1995, No. 410 "About the procedure of activities of the Russian physical and legal entities for the development of mineral resources of the seabed outside the continental shelf
Singapore	Deep Seabed Mining Act (2015)
Tonga	Tonga Seabed Minerals Act (2014)
Tuvalu	Tuvalu Seabed Minerals Act (2014)

the United Kingdom	Deep Sea Mining (Temporary Provisions) Act 1981 (amended by the Deep Sea Mining Act 2014)

The legislative framework in the EEZ

Although most countries have focused on deep sea mining in the Area, many countries have significant mineral resources within their EEZ. Ferromanganese crusts and phosphorites are especially abundant within the EZZ. The interest in the extraction of these resources has made countries develop regulations for activities related to deep sea mining in their own EEZ. Pacific Island nations, Japan, New Zealand, Australia, Mexico, and Namibia are some countries known to explore or pursue various forms of seabed mining within their national waters (Singh & Hunter, 2019).

A State must take suitable measures to control any deep seabed mining activities under its territory. According to UNCLOS, a wide range of obligations must be applied by states to protect the marine environment under their jurisdiction, including establishing laws and regulations to prevent, reduce and control pollution of the marine environment from seabed-related activities within their jurisdiction (UNCLOS, 1982-Art.208:209). This legislation on the management of deep sea mining must be no less effective than international standards, regulations and procedures, at least as restrictive as the ISA Prospecting and Exploration for mineral resources (Willaert, 2019).

4.1.1. European countries

In the case of maritime areas under the jurisdiction of the OCTs of Member States, in brief, deep-sea mining must be undertaken under the laws of those OCTs, which may or may not be the same as the laws applicable in the Member States with which those OCTs are connected. The applicable law should affect the requirements of international law even though the OCTs do not have the legal status of States recognised by international law.

4.1.1.1. France

The Mining Code, Law No. 68-1181 of 30 December 1968, relating to the exploration of the continental shelf and the exploitation of its natural resources, was implemented by Decree No. 71-360 of 6 May 1971, and by Decree No. 2006-798 of 6 July 2006, relating to the prospecting, research, and exploration of mineral and fossil substances in the seabed. A new Mining Code was established and went into effect in 2011. It makes particular provisions for the exploration and exploitation of mineral and fossil substances at sea on the continental shelf and in the EEZ (Ordonnance No2011-91 du 2011).

4.1.1.2. Germany

There are particular laws that apply to mineral exploitation from the EEZ and the continental shelf. However, the Baltic and North Seas are relatively shallow, with bottom depths not falling below 200 meters (Ordinance implements the Seabed Mining Act of 6 June 1995).

4.1.1.3. Portugal

Portugal is the only EU Member State to have enacted explicit law against seabed mining in areas subject to national jurisdiction, but not at the national level. The Portuguese Constitution declares that mineral resources are public property (Constitutional Law 1/2005 of August 12, 7th Amendment). The Portuguese legal framework for geological resource study and utilization was completely updated in 1990, with the entrance into effect of Decree-Law 90/90 of 16 March 1990 (92), which applies to both state and privately held geological resources.

In 2012, the Azores Autonomous Region enacted a unique legislative framework applicable to seabed mining, which provides economic control of the seabed's geological resources near the Azores archipelago. It is in addition to the legal framework for the exploitation of natural resources in the Azores approved by Regional Legislative Decree (Portugal, Regional Legislative Decree 21/2012/A of 9 May 2012). It comprises a collection of regulations that govern the procedures for prospecting, exploration, exploitation, research, right allocation, and land occupancy and expropriation.

However, the Constitutional Court recently ruled that these rules governing the marine mineral resources existent in the Portuguese maritime Area were unconstitutional, since their provisions violated Article 8(3) of the Statute of the Autonomous Region of the Azores.

4.1.1.4. Spain

In Spain, Law 22/1973, of July 21, 1973, on Mines (1973), establishes a legal framework for the discovery, research, and exploitation of mineral deposits and any other geological resource, regardless of origin or physical state. This law establishes that all natural mineral deposits and other existing geological resources found in Spanish territory, including the territorial sea and the continental shelf, are public domain goods that can be explored, investigated, and exploited directly by the Spanish State or transferred in accordance with the procedures and conditions outlined in this law and other applicable provisions in force.

4.1.1.5. Norway

Norway has begun projects linked to deep sea mining inside its sovereign territorial se as on the deep ocean floor of the Arctic area in recent years, with a special focus on Polymetallic Sulphides (Juliani & Ellefmo, 2018). In this regard, the Norwegian government has enacted legislation governing operations connected to the exploration and exploitation of mineral resources on the seabed and its substrates in Norwegian-controlled seas, including the continental shelf (Norwegian government. Law No. 7 of 2019). This Act governs mineral resources in Norwegian internal waterways, maritime territory, and the Norwegian continental shelf. Companies that wish to engage in any activity must file an environmental impact assessment and have it authorized by the Cabinet of Ministers. Mineral operations must not interfere with shipping, fishing, aviation, or any other activity, nor must they cause harm or provide a risk of damage to pipelines, cables, or other subsea facilities. The Act emphasizes the precautionary principle in order to minimize damage or contamination to the maritime environment and the seabed's cultural treasures. It also takes into account the fishing sector and the potential consequences it may face by compensating individuals affected by any deep sea mining activities.

4.1.2. Countries in the Pacific Ocean

The Pacific Ocean has a vast number of mineral resources in its seabed. A big part is located in the Area, but there are also located within the EEZ of some countries. This occurs within the national jurisdiction of powerful states such as New Zealand or Japan and in the territorial waters of small island countries. Because of the mineral extraction potential, all these countries are interested in developing a DSM regulation.

4.1.2.1. Japan

This country has 4,7 million square kilometres of EEZ, the height country with the most surface. There is a significant amount of mineral resources in the seabed and due to their need to reduce its dependency on external imports of critical metals, their economy has sought to develop its own resource supply, including in the Area and its EEZ (72).

In 1982, Japan adopted the Law on Interim Measures for Deep Seabed Mining (Government of Japan: Law on Interim Measures for Deep Seabed Mining, 1982). Deep sea mining in Japan's EEZ and continental shelf is regulated by the Mining Law, which applies to all mining (i.e., land mining, shallow water mining and deep sea mining) and regulates mining activities in both land and marine zones under Japan's national jurisdiction. Deep sea mining in Japan's EEZ and continental shelf is regulated by the Mining Law, which applies to all mining (i.e., land mining, shallow water mining and deep sea mining) and regulates mining activities in both land and marine zones under Japan's national jurisdiction. However, the law was drafted primarily with land-based mining in mind. Some of the crucial points of its recent changes relate specifically to the regulation of marine mining. These amendments took place in 2011.

There is no environmental policy in these regulations. However, offshore mining activities within areas under Japan's national jurisdiction are subject to various laws related to maritime safety and protection of the marine environment, including those addressing dumping and the establishment of safety zones. Including the Basic Environment Law (1993), the Act on Prevention of Marine Pollution and Maritime Disaster (1970), the Environmental Impact Assessment Law (1997) and others (Singh & Hunter, 2019).

4.1.2.2. New Zeeland

Exploration for subsea mining is ongoing in New Zealand (NZ), which contains reserves of Polymetallic Sulphides deposits and Polymetallic Nodules in its EEZ of more than four million square kilometres (Lamping, 2016). Two organs regulate Seabed Mining: The Crown Minerals Act 1991 and the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act (New Zealand Government, 2012), which manages the environmental effects of numerous activities, including SMS mining, beyond the 12 nautical mile limit (Boschen et at., 2013). Under the EEZ Act, the Environmental Protection Authority (EPA) is responsible for managing the effects of activities such as seabed mining in areas beyond the territorial sea, precisely defining mining activity to include "areas of the seabed which may contain mineral deposits," as well as "the extraction of minerals from the sea or seabed, and the processing of such minerals." All activities related to the DSM would require a publicly notified authorisation by the EPA, which involves submitting an application and an impact assessment and a nationally notified public process. The public can make representations and appear at a hearing and appeal decisions (New Zealand Government, 2012). The Authority is responsible for deciding factors like environmental and human health, biodiversity and species protection, existing interests, economic benefit, and other matters (New Zealand Government, 2012).

4.1.2.3. Small island states in the Pacific

These small states are located in the west pacific and their names are the Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Timor Leste, Tonga, Tuvalu and Vanuatu (**Fig. 8**). Despite the rapidly growing commercial interest in deep sea minerals, many Pacific nations do not have the necessary legal or management systems needed to ensure the responsible management of these critical natural resources. To help achieve a strong regulation for DSM activities, the EU started in 2011 the Deep Sea Minerals Project, collaborating with the Pacific Community (SPC) (SPC- EU Deep Sea Minerals Project, 2014). The project aims to help Pacific Island countries improve the governance and management of their deep sea minerals resources under international law, particularly with attention to protecting the marine environment and securing equitable financial arrangements (SPC- EU Deep Sea Minerals Project, 2014). In this context, EU-SPC launched a Regional Legislative and Regulatory Framework (RLRF) to help countries develop the national frameworks needed to improve their marine mineral resources (Lily, 2012). In this

context, some countries have developed or are developing DSM related legislation. The countries with the most advanced regulations are Papua New Guinea, Tonga and Cook Islands (ISA National Legislation Database, 2019).

4.1.2.4. Papua New Guinea

Until 2018, this was the first country to carry out a commercial undersea mining operation in its territorial waters, making the current legislation on this issue of particular interest. The Canadian company Nautilus Minerals intended to mine mainly gold and copper associated with hydrothermal vents at depths of approximately 1600m. Due to financial problems, the company was unable to continue with the operation and at the end of 2019, it declared bankruptcy and the operation was stopped.

There is no specific legislation on deep sea mining in Papua New Guinea. The Mines Act 1992 regulates minerals and mining but is designed for land-based operations. It declares that all minerals are the property of the national government and is not explicitly mentioned the deep sea mining activities—the application of non-specific legislation for deep sea mining results in failures and gaps in regulation. The Act contains no mention of the precautionary principle, transboundary harm and almost nothing about environmental protection in general, with nothing about EIAs and only one environment-related mention.

However, following an application by the Canadian company Nautilus Minerals for the Solwara 1 deep sea mining project, an exploration licence was issued for deep sea exploration in Papua New Guinea territorial waters. This was done based on the reference that "the coast is the seabed up to 12 m from the mean low water level of the seas to depths that admit exploration for mineral extraction". The PNG authorities provide information on the different reservoirs available in their waters, as shown in the national geodata repository (CCOP-GSI).

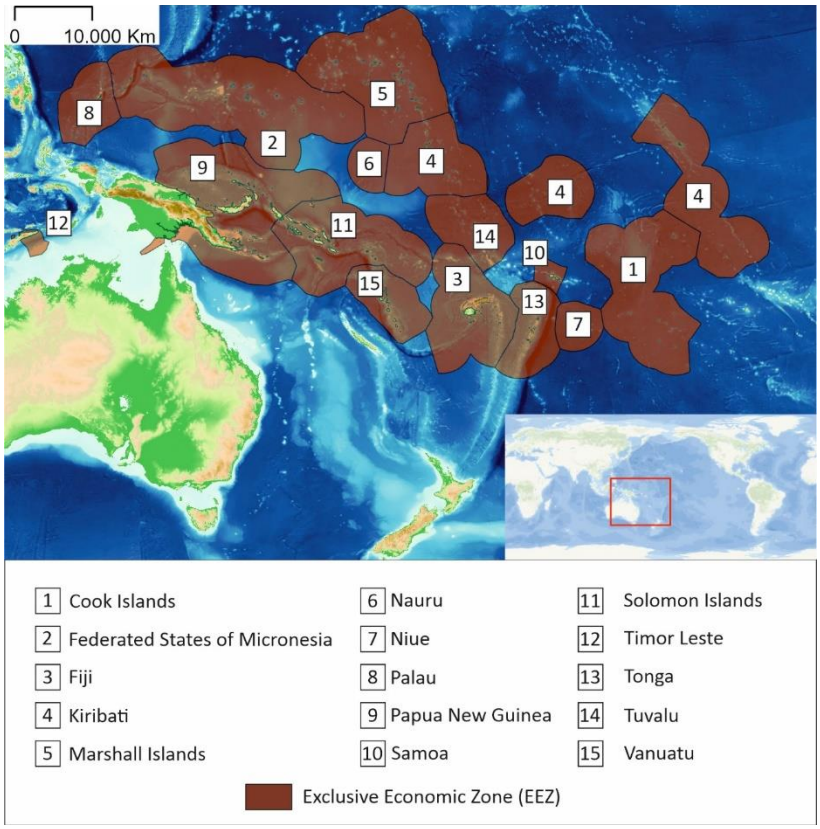

Figure 8. Countries member of the collaborating project between the EU and the Pacific Community (SPC- EU Deep Sea Minerals Project).

4.1.2.5. Cook Islands

According to estimations from the Cook Islands authorities, its EEZ contains around ten thousand tonnes of polymetallic nodules and the possibility of exploiting these resources is being explored (Cook Islands Seabed Minerals Authority, 2018). The Cook Islands is seeking to implement the SDM industry and is being actively advised by, among others, the EU and the International Monetary Fund on a regulatory and legislative framework. The Cook Islands has a Seabed Minerals Authority under the Minister of Finance and comprises a Seabed Minerals Commissioner, a Legal Advisor, and a Natural Resources Advisor (funded by the Commonwealth Secretariat) (72). Since 2016 the Cook Islands undertook negotiations with multinational companies and foreign governments regarding exploration within its EEZ and the Cook Islands' sponsorship of deep sea mining in the Clarion Clapperton fracture zone. In 2016, Cook Islands signed an exclusive agreement with Ocean Minerals to explore mineral resources in its EEZ.

In terms of legislation, the CI Parliament approved the Seabed Minerals Act in 2009, making it one of the first countries in the world with dedicated seabed mining legislation in the world (Cook Islands, Seabed Minerals Act. 2009). These regulations are very technical and the environmental protection measures it contains are weak. There are no extensive rules about the precautionary principle or the possible damage caused to adjacent areas. Another regulatory instrument is the Seabed Minerals (Prospecting and Exploration) Regulations (2015). It contains regulations for exploration and exploitation activities and a short section requiring deep sea mining companies to apply the precautionary approach, but it does not provide instructions on how to do so in the EEZ.

Nauru

Nauru is one of the sponsor states of Nauru Ocean Resources Inc (NORI), a wholly owned subsidiary of **The Metals Company**. This Canadian company founded in 2021 through the merger of **DeepGreen** and an organisation that expects to begin nodule mining in 2024. The ultimate goal is to mine polymetallic nodules from the ocean floor at depths above 4500 m in the Clarion-Clipperton Zone (CCZ) in the North Pacific Ocean between Hawaii and Mexico. The Metals Company has agreements with Nauru, Tonga and Kiribati for exploration rights in the CCZ.

In June 2021 Nauru notified the ISA of their request to finalize decisions regarding the exploitation regulation in the way to start an exploitation operation withing the area, though a letter from the president. They requested that the Council of the ISA complete the adoption of the rules, regulations and procedures necessary to facilitate the approval of plans of work for exploitation in the Area pursuant to Section 1, paragraph 15 of the 1994 Agreement relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea.

The deadline is set at two years; the two-year rule allows for a mining plan to be approved after two years under whatever rules are in place at that time (**The Guardian**). In an official statement, the ISA acknowledged Nauru's request and said it intended to resume work on the mining regulations this year, after progress was hampered in 2020 due to COVID-19 travel restrictions (**Ocean Mining Intel**).

5. Seabed Mining operations on continental shelves

Actually, any deep sea mining project is extracting mineral resources from the seabed, except for diamonds in the continental shelf of Namibia. Around the world, there are some seabed mining projects with a license for mining operations. In Papua New Guinea by Deep Sea Mining Finance Limited (Nautilus Mineral before) (Miller et al., 2018) and in the Red Sea by Diamond Fields International (Petersen et al., 2018), but they don't start yet.

Additionally, New Zealand, Norway, Tonga, Japan, Fiji, Solomon Islands and Vanuatu have permitted research to assess the mining viability or issued exploration permits for national seafloor, although some of these permits have lapsed (Levin et al., 2020). There are also exploration activities planned in the Cook Islands for polymetallic nodules and cobalt crusts and polymetallic nodules in Brazil (Marques et al., 2019).

Table 5. Some Deep Sea Mining projects have been developed or are being developed within the EEZ of some countries. Those projects currently active are shown in italics. PMS, Polymetallic Sulphides. Clicking on the source box, more available information is available.

Contract holder (country of registration)	Location	Type of mineral	Status (year awarded if known)	Source
Diamond Fields International (Canada)	Atlantis II Basin. Red Sea	PMS	*Mining contract, active (2010). Project currently on hold because of contractual issues with partnership company*	↗
Diamond Fields International (Namibia)	Namibia	Diamonds	*Mining contracts x4. active (2009. 2007 & 2007; 2000 is pending renewal: expected contract renewal as of November 2017)*	↗
Diamond Fields (South Africa).	Western Cape. South Africa	Phosphorites	Prospecting contract, active (2014)	↗
Trans-Tasman Resources (New Zealand)	South Taranaki Bight, west coast of North Island	Iron ore sands	*Three projects with an exploration permit, a mining permit and a prospecting permit.*	↗
Trans-Tasman Resources (New Zealand)	Westland sands. Ross to Karamea, west coast of South Island	Iron ore sands	Prospecting contract, active (2016)	-
Chatham Rock Phosphate (New Zealand)	Chatham Rise, east side. South Island	Phosphorites	*Mining contract, active (2013). The company refused environmental mining consent approval (2015).*	↗
Bluewater Minerals (Solomon Islands) Ltd. (Solomon Islands)	Temotu and Western provinces. Solomon Islands	PMS	Prospecting contract, active (2007)	↗

Green Rash Trading 251 (South Africa)	Groen River to Cape Town. South Africa	Phosphorites	Prospecting contract, active (2014)	↗
Green Rash Trading 257 (South Africa)	Cape Town to Cape Infanta. South Africa	Phosphorites	Prospecting contract, active (2014)	↗
Namibian Marine Phosphate (Pty) Ltd. (Namibia)	Sandpiper Marne Phosphate Project. Walvis Bay. Namibia	Phosphorites	*Mining contract, active (2011). Project pending EIA approval (June 2017).*	↗
NORA (Norway)	Norway, Mid-Atlantic ridge	PMS	*Exploration licenses for several prospective areas (2010)*	↗

6. Status of knowledge in Deep Sea Mining related issues

As is known, DSM focused much attention in the last years due to the high interest in harvesting the mineral resources presents in the seabed (eg., GeoERA-MINDeSEA, EGDI datasets). Factors like financial viability of mining operations, technological innovations, global metal market and growing demand for critical elements essential in green tech have improved to this growing interest. In this context, there are various opinions from the scientific community, industry, policy makers, and NGOs (Sparenberg, 2019; Hunter et al., 2018) concerning the economic, social, and environmental availability of a seabed mineral extraction operation (Hallgreen & Hansson, 2021).

The most relevant aspects of the DSM are discussed in the following points, and some of the most important publications in each of the areas described are referred to. In addition to the information described below, a list of reports, documents and information, organised by subject area, has been compiled to help further study in the field of the DSM. This can be found in the Appendix I.

Deep sea minerals for the green transition

The world's population is growing and new alternative sources of minerals to terrestrial ones are required to meet the increasing demand (Hein et al., 2013). This new society needs to move away from fossil fuels and switch to energy from renewable sources. This will require large quantities of critical minerals (**Fig. 9**) and DSM is a viable option (Mukhopadhyay et al., 2019).

At present, all of these high-tech required minerals are mined on land and due to the difficulties of finding deposits with a high degree of concentration, the mining industry is being forced to explore and exploit deposits in remote zones and with a lower tonnage. This is associated with an increase in land use and negative environmental consequences such as loss of biodiversity or pollution of protected areas (Sonter et al., 2018). The demand for raw materials such as copper, nickel and cobalt, which can also be found in the deep sea, will be strongly stimulated by the worldwide expansion of E-mobility (Petersen et al., 2020). In EU context the supply of Crítical Raw Materials (**CRM**) (**Table 6**) for clean technologies is a strategic question due to the dependence of Europe from 3rd countries and there exist a need to find sustainable sources (European Green Deal, 2020).

According to Hein et al. (2013) and the World Economic Forum (2019), the greater quality and potential for lower environmental and social consequences make marine mineral resources an appealing option to terrestrially

derived metals. According to the present conventional economic development status, demand for e-tech elements will continue to rise fast, influencing emerging nations' ability to transition to a sustainable clean energy society (Miller et al., 2018).

Table 6. List of EU critical raw materials. In green those abundant in deep sea mineral resources. Source: (**CRM**)

2020 critical raw materials		
Antimony	Hafnium	Phosphorus
Baryte	Heavy Rare Earth Elements	Scandium
Beryllium	Light Rare Earth Elements	Silicon metal
Bismuth	Indium	Tantalum
Borate	Magnesium	Tungsten
Cobalt	Natural graphite	Vanadium
Coking coal	Natural rubber	Bauxite
Fluorspar	Niobium	Lithium
Gallium	Platinum Group Metals	Titanium
Germanium	Phosphate rock	Strontium

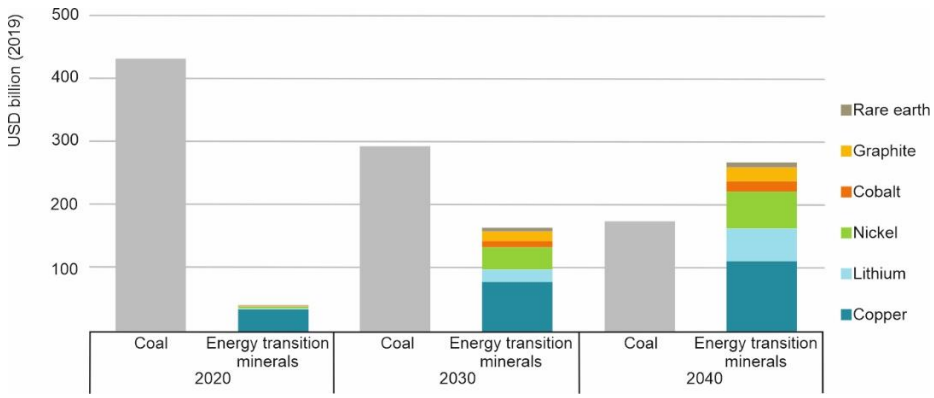

Figure 9. Revenue from the production of coal and selected energy transition minerals. Revenue for energy transition minerals includes only the volume required in clean energy technologies, not total demand. Modified from: **International Energy Agency (2019).**

DSM is an emerging industry that has not yet been proven. Despite this, many argue that the potential impacts of mining at sea will be less than on land due to the reduced need for significant infrastructure and transport systems (Koschinsky et al., 2018). In addition, this would considerably reduce deforestation and pollution of land-based water resources (Hein et al., 2013; Lodge & Verlaan, 2018). Also, mining deep-sea polymetallic nodules are calculated to release less CO_2 per kg than mining on land (Van der Voet et al. 2019). In this context, proponents of DSM not only present it as a means to ensure economic growth (Kim, 2017) but also as the potential start of a sustainable path, alternative to the current one, which could potentially help the transition to renewables and a sustainable future (Haugan et al., 2019).

Like any other extractive activity, DSM will have impacts on the environment, and effective and efficient regulatory systems will be necessary to be considered an alternative to land-based mining (Koschinsky et al., 2018). Although any industrial deep sea extraction project exists yet with terrestrial mining operations, it is argued that DSM would potentially have fewer needs for vast infrastructure and transport systems. Roads to mining sites, deforestation, large on-site buildings, and polluted nearby waterways would be avoided in the deep sea (Childs, 2018). Additionally, DSM will carry fewer social and economic impacts on human populations with less displacement of indigenous people close to mining-sites, and hazards to personnel would be more minor or

even non-existent (Lodge & Verlaan, 2018). The key to DSM's viability is that the restoration and pollution mitigation practices are environmentally and economically solid (WEF, 2019).

Advances in Deep Sea Mining technology

Extractive operations involving deep sea mining necessitate the use of technology that is still in the early stages of development. Currently, most machines under development are based on the pump-pipe lifting approach (Millet et al., 2018). This comprises heavy operational equipment, ore transport equipment, and surface support equipment. The environmental conditions, like pressure and temperature that occur on the seabed below 3000 meters water depth need highly advanced equipment capable of operating in such severe circumstances (**Fig. 10**). This technology has advanced over the years to the point that viability tests for this sort of machine have been successfully completed (**Table 7**).

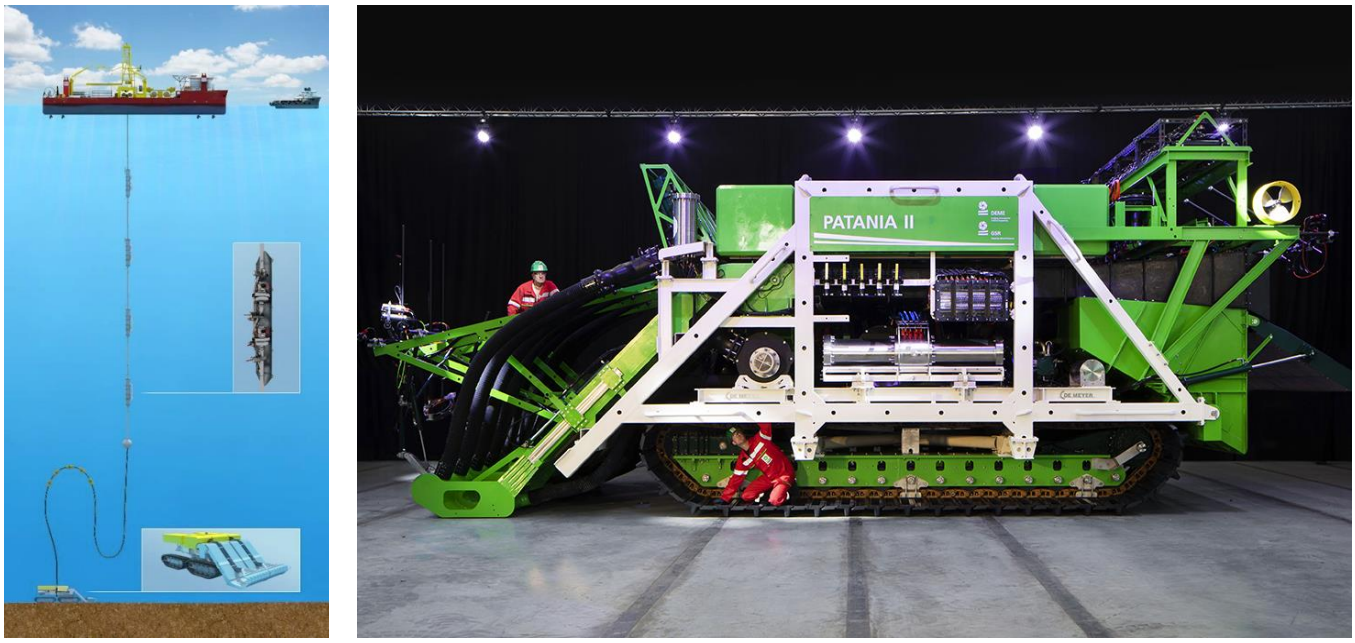

Figure 10. **Left:** Scheme of seabed mining extraction operation. Source: **IHC**. **Right**: Patania II nodule collector from Belgian GSR company. Source: **GSR.**

In 2018 **Blue Nodules** project, funded by the EU under the Horizon 2020 program, made a successful trial in the Gulf of Malaga (Spain) to test mining system for harvesting polymetallic nodules from the deep-sea floor with minimum environmental impact. In May 2021, Patania II, a pre-prototype polymetallic nodule collector developed by Global Sea Mineral Resources (**GSR**), was trialled at a water depth of 4,500 metres in the Clarion Clipperton Zone (CCZ). The robot successfully demonstrated its ability to drive on the deep seabed and collect nodules (**Fig. 10**). In 2020, Japan Oil, Gas & Metals National Corporation (**JOGMEC**) launched its excavation trials with the marine resource research vessel Hakurei with 1430 pounds of sands and rocks taken to the surface, at a depth of 1600m, from cobalt-rich crust on the seabed of Japan's exclusive economic zone. In April 2021, the Indian National Institute of Ocean Technology (**NIOT**), completed a research cruise to test new deep-sea mining equipment, survey potential ore prospects, and attempt the deepest seabed crawler test yet conducted. This 8-tonne machine made a successful trial to 5,270 metres deep down into the Indian Ocean.

Table 7. Summary of some deep sea mining crawler successfully tested.

Year	Country-Project	News	#
2020	Blue Mining (EU founded project)	"The Blue Nodules project will develop a new highly-automated and technologically sustainable deep sea mining system for the harvesting of polymetallic nodules from the sea floor"	↗
2021	Global Sea Mineral Resources (GSR)	"GSR Concludes Successful Trial of Deep Ocean Technology"	↗
2020	Japan Oil, Gas & Metals National Corporation (JOGMEC)	"JOGMEC Harvests Cobalt and Nickel from the Seafloor"	↗
2021	Indian National Institute of Ocean Technology (India)	"NIOT crew creates history as they undertake world's deepest underwater trials of mining machine"	↗

7. Maritime Spatial Planning and Environmental Issues related to Deep Sea Mining

Maritime spatial planning

Maritime spatial planning (MSP) is the tool to manage the use of our seas and oceans coherently and to ensure that human activities take place in an efficient, safe and sustainable way. Nature conservation, renewable energy, fishing, aquaculture, shipping, tourism, seabed mining and other uses compete for maritime space, taking place in pan-European seas. That is why the EU has legislation on maritime spatial planning (EC, 2014) with the following goals: 1) reducing conflicts and creating synergies between different activities; 2) encouraging investment through predictability, transparency and legal certainty; 3) increasing cross-border cooperation between EU countries to develop renewable energy, allocate shipping lanes, lay pipelines and submarine cables etc; 4) protecting the environment by assigning protected areas, calculating impacts on ecosystems and identifying opportunities for multiple uses of space. Marine Spatial Planning (MSP) is spreading across the globe as a new way of achieving sustainable development of the world's seas and oceans. EC has funded projects in the European and international framework supporting the implementation of the MSP legislation. In 2021 all the coastal EU countries have established maritime spatial plans and they will be reviewed at least every ten years.

Seabed ecosystem

Like any other activity in the seabed, DSM has potential environmental impacts and this is known a long time ago (Thiel *et al.*, 1991). There are many aspects from the environment, physical, chemical, or biological, that can be modified by the activities related to the exploration and exploitation of mineral resources in the seabed. Some of the impacts are common to all types of DSM (e.g., sediment plume), but others are specific to certain deposits types, for example, specific benthic communities present in the manganese nodules field (Weaver *et al.*, 2018).

The main impacts produced by the DSM in the ecosystem are habitat destruction and/or modification of the environment, impacts related to the dispersal of sediment plume generated during the mining process in the seabed and the water column and impacts related to other factors like sound or light (Weaver *et al.*, 2019).

It is important to note that the three principal mineral resources: polymetallic nodules, ferromanganese crusts, and massive sulphides, are linked to specific ecosystems, each posing different environmental issues and will be exposed to different impacts.

- **Manganese nodule fields** have a great diversity of organisms in the sediment, attached to the nodules and in the water column above the seabed. There are discovered benthopelagic organisms that occur in this seabed zone (Billett *et al.*, 1985). In addition, these fields are an important region for the dispersal of larvae from benthic organisms (Vanreusel *et al.*, 2016). Due to the difficulties in surveying these areas, there is not enough information to understand why such high species diversity occurs and how different species interact. What is known is that the manganese nodule fields are placed in remote zones with a very stable environment with meager sedimentation rates and generally low input of food (Smith 2013).
- **Ferromanganese crusts** are present in the top and upper flanks of seamounts in a water range of 800-2500 m (Hein and Koschinsky, 2014). Due to the lack of sediments, the hard surfaces provide anchorage points for sessile filter-feeding animals and some of these, such as corals and sponges, provide structural habitat for many other species (Nalesso *et al.*, 1995). The flanks of the seamounts occupy a broad depth range with different species occupying different depth ranges, and thus many different species can be found on single seamounts (Clark et al., 2010). Apart from the corals and sponges, a wide range of species has been recorded from seamounts, including squids, sea stars, sea cucumbers, crabs and large foraminiferas (Fukushima 2004).
- **Massive sulphides deposits** are present in zones with the occurrence of hydrothermal vents. Fluid flush is the key source of energy for a complex ecosystem. The biological communities that inhabit this system are bacteria, shrimps, tubeworms, crabs, and others adapted to life in extreme conditions (Fisher *et al.*, 2013). These chemosynthetic organisms have a limited distribution because they are confined to sources that are limited to small areas distributed along oceanic ridges (Weaver & Billett, 2019). One of the main characteristics of these areas is the high rate of recovery of the ecosystem associated with these areas due to their high rate of colonisation (Gollner et al., 2017). Those zones without present-day hydrothermal vent communities may have little impact on loss of habitat because deep-sea taxa associated with them will be more typical of rocky slope fauna, which is more extended along the seabed.

Potential impacts on the environment

There will be a direct and indirect impact on the environment and the surrounding during exploitation activities, which is not avoidable. Depending on the resource type, there will be different impacts, but the same impacts are common to all. These are mid water plumes, noise and light.

7.1.1. Sediment plumes

Mining for any of the three resources will be done through a collector that will operate on the seabed and through a pipe that will transport all the material to the ship on the surface. Once on the surface, the solid part will be separated from the liquid and sediment, which will be returned to the sea (Weaver *et al.*, 2018). This discharge is known as the water plume and depending on the depth is done the impacts will vary. The introduction of large volumes of small particles into the ocean could affect mid-water organisms by clogging up their water mechanisms if high concentrations (Yamazaki *et al.*, 2000). In the case of sulphides extraction, toxicity

is also a relevant factor. The ocean column is stratified, the water masses have different physic-chemical proprieties and returned water may have different properties than the water to which it is added, e.g., temperature and pH. An alteration of these factors could affect living organisms, and changes in oxygen content or the presence of elements such as iron could lead to changes in plankton and/or microbial populations (Gollner *et al.*, 2017).

This sediment plume´s behaviour has been studied in depth to predict how it will impact the environment and minimize the damage (e.g., Aleynik *et al.*, 2017; Rzeznik *et al.*, 2019). According to a recent study (Muñoz-Royo *et al.*, 2021) carried out in Clarion Clipperton Fracture Zone, the properties of midwater sediment plume were reliably modelled in the vicinity of the discharge.

7.1.2. Noise

Noise and vibrations generated during the operation phase are mainly due to the collector, the pipe connecting to the surface and the ship (Bassila *et al.*, 2019). Any noise and vibration generated in the water can travel long distances and it is, therefore, necessary to pay attention to the impact they can generate. Some marine animals have a sensitive auditory system and perceiving louder signals than usual could lead to rejection reactions or even physical damage (Drazen *et al.*, 2020). Sound can impact all water depths but may be a problem at depths up to 2000 m, where it can interfere with marine mammals. The positioning of pumps along the vertical conveyance or riser should be controlled for the impact they may have on fish and invertebrates, as well as the marine mammals that feed on them (Weaver *et al.*, 2018).

7.1.3. Light

Lights will be required during extraction activities in underwater mining. Even though light does not penetrate beyond a few hundred meters, many organisms living in the water column have very high photosensitivity (e.g., pelagic and avisal fishes have highly developed eyes that can detect very faint light sources) (Weaver *et al.*, 2018). Some deep-sea fish species may avoid or be attracted to artificial light, so the presence of artificial light may be detrimental to them. Most deep-sea invertebrates also have light receptors, and artificial lights can severely damage invertebrates' eyes or even blind them permanently (Moskvitch 2014). Bright artificial light can also obscure or completely block the function of bioluminescence, which is essential for deep-sea organisms to, for example, orient themselves, communicate, find food, mate and defend themselves from predation.

Status of knowledge

Due to the increasing interest in extracting seabed mineral resources, various governmental organisations, research institutes, universities and environmental associations have developed knowledge associated with this emerging sector. As a new industry, the technology, environmental foundations, and associated legislation are being developed to ensure that an extractive operation is technically and environmentally sustainable. It should be noted that DSM is not an issue limited to the mining industry; all developments must be in line with environmental sustainability policies. To achieve this goal, some critical issues related to the DSM require more research. Those are an improvement in the scientific knowledge of deep sea ecosystems, improvement in the technology needed for deep sea mining operations and improvement in a regulatory framework able to establish limits to the environmental impact.

A lot of the data required for this kind of study must be taken in situ, what require complex and expensive oceanographic campaigns due to the study area's remote location (Clarion Clipperton Fracture Zone, Mid Atlantic Ridge or Central Indian Ocean basin). Nevertheless, there is a pressing need for resources dedicated to such

activities (Boetius and Haeckel 2018). Standardizing data collection methods and plans for more exhaustive environmental surveys along the ISA contractor's areas are fundamental challenges to accurately assess the regional environment and impacts (Shirayama et al., 2017).

As was mentioned before the current state of legislative development in the DSM framework is in progress. This is necessary in order, on the one hand, to establish a regulatory framework for a new industry in which the activities carried out have a minimal impact on the environment. On the other hand, the regulation must address uncertainties and unknowns that still exist. These regulations must be in line with the law established in UNCLOS and be applicable in all mining nations. One way forward would be to apply the precautionary approach, adopted by the Rio Conference, or Earth Summit, in 1992 (UNCED 1992).

In the context of the development of deep-sea mineral resources, efforts are repeatedly made to catch up with environmental conservation plans pursued by international communities, including the UN and the EU. This increasing interest has been exposed during the G7 Summit held in Elmau (Germany) in 2015. A declaration said, "We call on the International Seabed Authority to continue, with early involvement of all relevant stakeholders, its work on a clear, effective and transparent code for sustainable deep sea mining, taking into account the interests of developing states". During de G20 held in Rome (Italy) in 2021 in a report they declare "We highlight the importance of making progress in the ongoing negotiations for an ambitious and balanced international legally binding instrument under UNCLOS, for the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction (BBNJ). In the context of the ISA we support the development of International seabed mining regulations, in line with the precautionary approach, that results in the effective protection of the marine environment."

In addition, projects on environmental impact assessment/conservation measures with deep-sea mining have been developed focusing on the critical aspects. Some projects can be seen in **Table 6**. In the Blue Mining project (2014-2018) (Blue mining 2015), 19 research centers and companies from 6 EU countries have participated. Its field of work has been developing technology associated with the exploration and exploitation of mineral resources using technologies such as UAVs. The Blue Nodules project (2016-2020) (Blue nodules 2016) has involved 14 research centres and has developed a technologically sustainable deep sea mining system to harvest polymetallic nodules from the seafloor. Within GeoERA Raw Materials program has developed Seabed Mineral Deposits in European Seas: Metallogeny and Geological Potential for Strategic and Critical Raw Materials (MINDeSEA) due to the collaboration between 8 GeoERA Partners and 4 Non-funded Organizations between 2018-2021 (MINDeSEA 2018). The project aimed to develop an integrative metallogenetic study of principal types of seabed mineral resources (hydrothermal sulphides, ferromanganese crusts, phosphorites, marine placers and polymetallic nodules) in the European Seas.

Environmental impact assessments have also become increasingly crucial as expectations for the development of seabed mineral resources. The EU has also launched the MIDAS ("Management of Impacts of Deep Seas Resources Exploitation") (2013-2016) programme as part of the Seventh Framework Programme (MIDAS 2013). The objective was to reduce the environmental impact of deep-sea mineral resource exploitation. They were principally focused on polymetallic nodules, seabed hydrothermal deposits, ferromanganese crusts, and rare-earth mud. 32 partners formed the programme from 11 European countries related to science, industry, social sciences, law and NGOs. Not funded by the EU, the Joint Programming Initiative Healthy and Productive Seas and Oceans (JPI Oceans) (2015-2017) are supported by EU countries collectively (JPI Oceans 2015). One of the JPI Oceans research projects focuses on exploring deep sea resources, and its objectives include establishing deep-sea habitat maps for deep-sea mining areas. Mining Impact: Environmental impacts and risks of deep sea mining project (2018-2022), the second phase of the JPI Ocean project, is currently taking place with the cooperation of

30 partners from 11 different countries (104 JPI Oceans 2018). The objectives are to assess the large-scale environmental impact caused by the suspended sediment plume, (2) the regional connectivity of species and biodiversity of biological assemblages and their resilience to impacts, and (3) the integrated effects on sea bed ecosystem functions.

In recent years, many studies have been carried out to understand the potential damage that underwater mining could cause to the environment. To this end, different variables have been studied, such as habitats or physical and chemical changes in the sediment. A study carried out in one of the nine Areas of Particular Environmental Interest (APEIs) implemented by the ISA in CCFZ shows that this particular area is partially representative of an exploration area nearby located (Jones *et al.,* 2021). In the same area, another study using metazoan megafaunal data simulated a range of very low to severe disturbances to determine the effect on community-level metrics (Ardron et *al.,* 2019). Also, in CCFZ, the seamounts habitats were studied to understand their distribution during a mining activity (Cuvelier *et al.,* 2020).

Table 8. International scientific research projects related to Deep Sea Mining

Project	Members	Dates	Link
Blue Mining	19 research centres and companies from 6 EU countries	2014-2018	
Blue Nodules	14 research centres from 9 EU countries	2016-2020	
MINDeSEA	8 GeoERA Partners and 4 Non-funded Organizations	2018-2021	
MIDAS	32 Organizations from 11 EU countries	2013-2016	
JPI Oceans	25 partners from 11 EU countries	2015-2017	
JPI Oceans: Mining Impact	30 partners from 11 EU countries	2018-2022	

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9. APPENDIXES

APPENDIX I: Relevant reports, documents and information

Name	Description	Year	Source
United Nation Convention Law of the Sea (UNCLOS)	It defines the rights and responsibilities of nations with respect to their use of the world's oceans, establishing guidelines for businesses, the environment, and the management of marine natural resources.	1982	
	Documents by International Seabed Authority (ISA)		
The Mining Code: Exploration Regulations	Regulatory documents regarding exploration contracts in the Area for Ferromanganese Crusts, Polymetallic Sulphides and Polymetallic Nodules	2010, 2012 and 2013 respectively	
Draft Exploitation Regulations	Draft regulations for exploitation of mineral resources in the Area developed in accordance with UNCLOS	2019	
The Mining Code: Recommendations	Recommendations to guide contractors in achieving the key technical and environmental issues of the Mining Code	2013-2019	
Standards and Guidelines	Standards and guidelines developed by ISA to support the implementation of the regulations of the "draft regulations on exploitation of mineral resources in the Area"	2019	
Exploration Contracts: Minerals: Polymetallic Nodules	Compilation of all contractors with Nodule exploration blocks in the Area and information about them	2001-2021	
Exploration Contracts: Minerals: Polymetallic Sulphides	Compilation of all contractors with Polymetallic Sulphides exploration blocks in the Area and information about them	2011-2018	
Exploration Contracts: Minerals: Cobalt-rich Ferromanganese Crusts	Compilation of all contractors with Cobalt-rich Ferromanganese Crusts exploration blocks in the Area and information about them	2014-2018	
Exploration areas	Maps and shp. of the areas where the exploration contracts are located. Classified by resource and region	2019-2021	
Reserved Areas	Location maps referred to reserved areas contributed by contractors from developed countries to the ISA	2020-2021	
Environmental Impact Assessments (EIA)	Publicly available EIA documents submitted by contractors	2018	
National Legislation Database	A collection of laws, regulations and administrative measures with regard to activities in the Area is based on submissions made by UNCLOS member states	-	
Secretary-General Annual Report	It is a graphic report in which the ISA documents all the activities of ISA between July 2019 and June 2020	2020	

Study of the Potential Impact of Polymetallic Nodules Production	Is a Study of the Potential Impact of Polymetallic Nodules Production from the Area on the Economies of Developing Land-based Producers of those Metals which are Likely to be Most Seriously Affected	2020	
EU related deep sea mining reports			
Study to investigate the state of knowledge of Deep Sea Mining	This interim report provides an overview of the most important aspects of the Deep Sea Mining in Europe and the world until March 2014.	2014	
The EU Blue Economy Report 2021	This report provides an overview of the performance of the EU-27 economic sectors related to oceans and the coastal environment	2021	
Deep Sea Minerals and the Green Economy	This report provides an integrated examination of the key aspects of mineral extraction, including the geological, biological, technical, social, economic, and fiscal components in the context of Pacific Island States (SPC)	2013	
Deep Sea Minerals: Cobalt-rich Ferromanganese Crusts	A physical, biological, environmental, and technical review of Cobalt-rich Ferromanganese Crusts in Pacific Island States (SPC)	2013	
Deep Sea Minerals: Seafloor Massive Sulphides	A physical, biological, environmental, and technical review of Seafloor Massive Sulphides in Pacific Island States (SPC)	2013	
Deep Sea Minerals: Manganese Nodules	A physical, biological, environmental, and technical review of Manganese Nodules resources in Pacific Island States (SPC)	2013	
Deep Sea Minerals: Summary highlights	This report collects all the key points of the SPC reports made for Manganese Nodules, Seafloor Massive Sulphides and Ferromanganese Crusts	2013	
Pacific-ACP States Regional Legislative and Regulatory Framework for Deep Sea Minerals Exploration and Exploitation	This legal framework document is designed to assist Pacific Island States in their development of national policy and law for Deep Sea Mining	2012	
European Green Deal	It talks about the European government´s commitment to tackling climate and environmental-related challenges necessary to achieve a sustainable society	2019	
At a crossroads: Europe's role in deep-sea mining	This report has been developed by "SEA AT RISK". provides an analysis of the existing policies and positions of the European Union and its Member States as well as of Norway and the UK in relation to DSM and connected Green Deal and raw-materials strategies.	2021	
Atlantic Seabed Mapping Roadmap	This report talks about the roadmap for a baseline map of the seabed and habitats of the Atlantic Ocean	2020	
Critical raw materials and green energy transition			

Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition	This report talks about the growing demand of mineral resources in a low-carbon future society and how clean energy technologies need more materials than fossil-fuel based electricity generation technologies	2020	
The Role of Critical World Energy Outlook Special Report Minerals in Clean Energy Transitions	This report provides a comprehensive analysis of the complex links between minerals and the prospects for a secure, rapid transformation of the clean energy sector.	2021	
What Role for Ocean-Based Renewable Energy and Deep-Seabed Minerals in a Sustainable Future?	This paper examines how and to what degree energy from the ocean can contribute to the climate agenda and achievement of Sustainable Development Goal 7 (Affordable and Clean Energy), including identifying new solutions and their potential impact, as well as addressing related safety and environmental concerns.	2020	
Integrated Report Iberian market operator (OMI) Group 2019	The report talks about the changes and innovation in European energy sector. In particular energy transition and digitalisation.	2019	
United Nations Framework Classification for Resources	This report is a global classification and management system applicable to mineral, petroleum, nuclear fuel, renewable energy and anthropogenic resources, as well as water and injection projects for geological storage	2019	
Masterplan for a Competitive Transformation of EU Energy-intensive Industries Enabling a Climate neutral, Circular Economy by 2050	This report talks about the goals of European industry for the transition to a climate neutral, circular economy by 2050	2019	
Communication from the commission to the european parliament, the council, the european economic and social committee and the committee of the regions	The 2020 EU Critical Raw Materials List reviews the list of critical raw materials for the EU	2020	
Responsible and sustainable sourcing of battery raw materials	This report explain the European framework on raw materials needed to battery sector	2020	
Deep sea mineral resources in the current society			
Deep-Sea Minerals: What Manufacturers and Markets Need to Know	Brief report from World Economic Forum about the potential extraction of deep-sea minerals, written for manufacturers and market exchanges.	2020	
Deep-Sea Minerals: Why Manufacturers and Markets Should Engage Now	Examines the applicability to deep-sea minerals of existing responsible sourcing approaches and identifies gaps and possible environmental and social risk exposure for manufacturers.	2021	

The Potential of the Blue Economy - Increasing Long-term Benefits of the Sustainable Use of Marine Resources for SIDS and Coastal Least Developed Countries	This report, drafted by UN and the Wold Bank, talks about the importance of common understanding of the blue economy particularly for small islands	2017