Options to Improve Transparency and Effectiveness in the Environmental Monitoring System for Polymetallic Nodule Mining in "the Area"

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Abstract

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This thesis examines institutional innovations required for development and application of a system for monitoring environmental impacts of mineral mining on the deep seabed and in the overlying ocean, beyond national jurisdictions of the continental shelf, termed "the Area". The goal of this study is to recommend a monitoring system that is both effective and transparent.

Since it was established in 1994, the International Seabed Authority (ISA) has developed environmental regulations and recommendations for the prospecting and exploration of seabed minerals in the Area. The ISA drafted tentative new regulations on deep seabed mineral mining in the Area in 2017. The new regulations will potentially enter into force within about two years pending revision and ratification. That scenario would enable commercial mining in the Area to commence at any time following the initial two year period. However, a large number of stakeholders and scientists are concerned that: 1) there could be significant harmful impacts of mining on deep seabed biodiversity and water column ecosystems, and 2) the processes and results of evaluating such impacts by ISA or their designates, may not be transparent to concerned stakeholders. An adaptive approach to effective monitoring of the entire process, at least initially, is required to assess and mitigate harmful changes from mining in the marine environment of the deep seabed. Innovative techniques of monitoring the extraction process should be considered seriously from the early stages of a regulation development in tandem with other environmentally oriented strategies instruments, such as publishing environmental impact assessments which, in turn, are dependent on documented monitoring efforts. A cooperative, transparent, and integrated monitoring system should be implemented at the outset of mining to identify and assess potentially harmful impacts and to inform future strategies that could minimize marine ecosystem degradation.

Through examination of the ISA mining regulations, meeting reports and academic literature, this study found that the ISA monitoring system is currently lacking key elements of reporting compliance, a transparent review system, and information access system to all stakeholders. Six case studies of other international and national deep sea monitoring practices showed that the characteristics of this ISA monitoring plan is more similar to national monitoring in the Exclusive Economic Zones and that the ISA does not seek for regional and collaborative effectiveness in the environmental management of resources that constitute the "Common Heritage of Mankind" in open ocean/high seas portions of the global ocean (the Area). These more territorial characteristics indicate the ISA system may not be sufficiently flexible and adaptive to allow effective management of environmental changes in the international deep seabed and the overlying ocean.

In this thesis, I propose 19 institutional, and 6 technological, recommendations to the ISA, as options to create an idealized monitoring system for deep seabed mining of nodules in the Clarion Clipperton Region of the Area. These recommendations are described in detail and are based on practical examinations from the current ISA rules and inspection of other deep sea monitoring practices, taking into account stakeholders' perspectives to design an approach that is as mutually acceptable to all parties as possible. Therefore, this study suggests that the ISA system potentially could gain better outcomes for the environmental management in the Area, however, they need to consider various options thoroughly before commencement of deep seabed. Key recommendations include to define baseline monitoring strategies with respect to spatial and temporal resolution, to implement collective monitoring and reporting by adjacent contractors, and to establish compliance review committees inside ISA.

Acknowledgments

This thesis was a challenge for me to synthesize my knowledge and expertise in deep sea sciences with policy analysis. I dedicate this thesis to my previous supervisors, the late Professor Masaki Kawabe, University of Tokyo and Professor Tamaki Ura, Kyushu Institute of Technology University for giving me many opportunities to engage in deep ocean research. I thank my mentors, Professor James Kraska at the US Naval War College, Professor Andreas Thurnner at the Lamont-Doherty Earth Research Institute of Colombia University, and Professor Michio Kumagai at Ritsumeikan University for their encouragement and advice in my research career. And my deepest gratitude is to my wonderful advisors and committee member at the School of Marine and Environmental Affairs and the School of Oceanography of University of Washington. I hope my work can improve deep sea management institutions with respect to monitoring of environmental conditions.

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Chapter 1. Introduction

1.1. Environmental monitoring of the impacts caused by seabed mining

Environmental monitoring is a necessary policy and management tool to observe effects of marine mining and compliance with environmental protection standards. Monitoring can avert harmful impacts caused by natural resource development projects and is part of Environmental Impact Assessments (EIAs). Monitoring is generally conducted in a post-decision stage during and after an EIA as the EIA follow-up activity (Morrison-Saunders, Arts, Baker, and Caldwell, 2001; Morrison-Saunders, Marshall, and Arts, 2007) in order to confirm the EIA outcomes and keep track of environmental conditions affected by the project (Ramos, Caeiro, and de Melo, 2004). It is known that the EIA follow-up monitoring can bring mutual benefits to proponents and regulators. Therefore, monitoring and well-planned EIAs are essential elements to consider from the beginning of program planning (Morrison-Saunders et al., 2001) and should be implemented from that stage.

Monitoring has been considered a necessary management process in seabed mining projects as well. The highest administrative and regulatory body to manage the deep-seabed mineral mining in the Area[1], the International Seabed Authority (ISA), has adopted and amended three regulations as legal instruments for the prospecting and exploration periods of three kinds of seabed minerals, i.e., polymetallic nodules, cobalt-rich ferromanganese crusts, and polymetallic sulphides–since 2000. It is going to develop another regulatory framework for the exploitation period of the three minerals. These rules contain the ISA mining contractors' obligations to conduct baseline surveys, EIAs, monitoring in the contracted area, and sponsoring nations' legal obligations to implement appropriate management rules to

[1] UN Convention on the Law of the Sea Article 1. The Area means seabed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction.

comply with the ISA regulations ("The mining code | International Seabed Authority," n.d.). However, a large amount of literature has pointed out that the ISA regulations are ambiguous and that they do not clarify the definition of harmful impacts, items to be observed and assessed in baseline surveys and EIAs, processes to be taken in EIAs, etc. (Collins et al., 2013; Durden et al., 2017, 2018; Ellis, Clark, Rouse, and Lamarche, 2017; Jaeckel, 2016; Jaeckel, Ardron, and Gjerde, 2016; Jaeckel, Gjerde, and Ardron, 2017; Levin et al., 2016).

As a fundamental issue of the deep-seabed mining in the Area, environmental data are extremely sparse in the deep sea, and the detailed biological system is still unknown. Thus, commercial mining activities on the deep seabed are considered to be premature because it is not possible to predict the mining impacts on the ecosystem (Beaulieu, Graedel, and Hannington, 2017; Van Dover et al., 2017). Not only from a science side, the ISA's regulations also require sponsoring states to apply "a precautionary approach" to the environmental protection in the Area from human activities based on one of the Rio Declaration principles (Regulation 31 Protection and preservation of the marine environment; (ISA, 2013b). Recently the United Nations has been in deliberations on a new biodiversity regulation which would legally bind state practices in the Area (The conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction; UN, 2017). The current movement toward the precautionary approach and conservation of biodiversity could require more protection of biodiversity in the ISA regime in the form of tighter EIAs and monitoring.

"An adaptive management approach" is another concept which is relatively recently recommended for ISA's environmental management. This term officially showed up in the draft regulations on exploitation of mineral resources in the Area (ISA, 2017a), where the adaptive management techniques are required to be applied in the monitoring program.

The Annex VII Environmental Management and Monitoring Plan

An Environmental Management and Monitoring Plan shall include the following information:

(g) A description of the planned Monitoring programme, standards, protocols, procedures and performance assessment of the Environmental Management and Monitoring Plan, including environmental objectives set and the necessary risk assessment and management techniques, including adaptive management techniques (process, procedure, response), to achieving the desired outcomes.

Ellis et al. (2017) argues that an adaptive management approach can reduce uncertainties in an EIA effectively analyzing the offshore mining practices in New Zealand. Durden et al. (2018) suggests that both precautionary and adaptive management approaches are necessary and that they should continue from an EIA throughout monitoring.

The current regulations and expert meetings held around the ISA on the monitoring system have mainly addressed scientific and technical perspectives, i.e., species and water properties to be monitored ("Workshop: Design of Impact Reference Zones and Preservation Reference Zones in the Area | International Seabed Authority," n.d.). These are important for the construction of the best available science. However, I would argue that synoptic policy mechanisms and processes to facilitate the use of such best available science should be considered and implemented, particularly the roles in monitoring among mining contractors, sponsoring states, and ISA. Additionally, the methods of reporting and review are important components of monitoring and should be discussed as well. Once actual mining starts, a large international organization may not be able to change quickly to revise a part of the system although some flexibility should be maintained.

1.2. Seabed mining in the EEZs and beyond

Historically, marine mineral resources in the seabed have been strong interests for nations since the 1950s at the time of Challenger Expedition (Allen, 2014). In the Antarctic Ocean, the Antarctic Treaty Parties once created a management plan for mineral mining (1988 Convention on Antarctic Mineral Resource Activities). However, some parties were not able to agree with the plan and this effort ended in banning the mining activity (Berkman et al., 2009). Until the UN Convention of the Law of the Sea (UNCLOS) entered into force in 1994, the US was one of the leading nations to explore deep-seabed minerals. It even conducted EIAs for test mining activities in the Central Pacific Ocean (United States, 1987) which is now where the ISA's most heavily contracted areas exist (16 areas). In all areas that the ISA manages, there are currently 29 mining contracted areas sponsored by nations (e.g., U.K., France, Germany, Japan, China, India, etc.) that have contracted with the ISA to proceed with mining exploration (ISA website, 2018). Some ISA contractors, such as the UK and Japan, have re-contracted with the ISA and have started their second term exploration period of fifteen years. They are waiting for the establishment of regulations to frame commercial mining activities in the Area, which are expected within fifteen years in the current legal setting. Even before the critical EIA framework has been created, it is not too early to consider the best monitoring practice and its components and frameworks.

In the EEZs of some nations sponsoring ISA contractors, such as Papua New Guinea, the Cook Islands, and Japan, seabed-mining projects have started already. For example, Papua New Guinea is the leading nation. They mine polymetallic sulphides from the offshore seabed at approximately 1600 m depth in the Bismarck Sea. The PNG government passed the Environmental Act in 2000 for seabed mining, and a Canadian mining company, Nautilus Minerals Inc., has been contracted to lead the Solwara 1 Project' since 2007. Nautilus' EIA was finished in 2008 based on the observation data collected since the 1990s, a large volume of outputs from expert meetings, and simulations (Coffey Natural Systems, 2008). This EIA is positively evaluated by some participating experts as they applied best practices in the EIA surveys and reviewed the EIA data with the collaboration of scientists and industry (Van Dover, 2011; Van Dover et al., 2016). Thus, the ISA technical workshops have referenced Papua New Guinea's practices. However, it should be noted that the progress toward commercial mining in the Papua New Guinea EEZ ceased in 2013 because of financial and mistrust problems between the company and the government (Davidson and Doherty, 2017). In the meantime NGOs and activist groups have strengthened their protests against the project in terms of environmental protection (“Deep Sea Mining,” n.d.; “MiningWatch Canada | Changing public policy and mining practices to ensure the health of individuals, communities and ecosystems,” n.d.). One argument of the NGO groups is that the government and Nautilus Minerals Inc. underestimate the potential impacts and risks in the EIS (Deep Sea Mining Campaign, 2015).

It is also noted that the Pacific Island nations, including Papua New Guinea, have developed an EIA scheme for mining in a regional cooperation process during the1990s under the aegis of a World Bank's project. They established the Pacific Community and Secretariat to the Pacific Regional Environment Programme (Bradley and Swaddling, 2016). However, the region has potential disadvantages due to its lack of trained marine mining expertise, insufficient quality control over EIA reports, weak compliance monitoring and enforcement, and a low level public engagement in EIAs.

Applicable monitoring techniques for the seabed are available from the offshore oil and gas development already commercialized in the EEZs. Nations have established their own laws, regulations and EIAs and monitoring systems. With the ease of access, higher economical value (Wakefield and Myers, 2016), and few environmental impacts per unit area (Hein et al., 2015), some experts recommend that the seabed mining should be more easily implemented in the EEZs, as opposed to in the Area (Hannington, Petersen, and Krätschell, 2017).

1.3. Policy elements in monitoring of the deep seabed mining in the Area

The ISA is attempting to make clear what items should be monitored and reported, who monitors and reports, how reports are reviewed, and who can access the reports and data. With respect to accessing data, transparency is considered necessary for good governance (Ardron, 2016; Ardron, Ruhl, and Jones, 2018; Mitchell, 1998). However, transparency in the current ISA system is evaluated to be very low, i.e., far worse than when other regional management organizations are considered, e.g., fisheries on the high seas (Ardron, 2016; Jaeckel et al., 2016). Ardron et al. (2018) defines six ways to enhance transparency as the access to information; reporting, quality assurance, compliance information/accreditation, public participation, and the ability to review and appeal decisions. They further recommend that the ISA should find implementation mechanisms for these methods to build confidence in its work.

In a realm of transparency of systems, Mitchell (Mitchell, 1998) defines an information system as the function of transparency in a regime (Fig. 1.2). The information system can input information to the regime through reporting and monitoring and output data to the regime and the public through reviewing, data sharing, etc., and ultimately can increase the effectiveness of the system. Here "effectiveness" does not mean the ability of a technical monitoring system to detect and identify impacts and to monitor the trends. This thesis will uses effectiveness as a function of "*the contributions that institutions make to solving the problems that motivate actors to invest the time and energy needed to create them*" (Young and Levy, 1999). Information systems are categorized as either effectiveness-oriented or compliance-oriented. Reporting is described a the most important source of information and categorized as self-reporting (reporting by monitoring practitioners), other-reporting (reporting by stakeholders other than monitoring practitioners) and problem-reporting (reporting by anyone who finds a problem). Mitchell emphasizes that transparency sources such as reporting activity are influenced by the incentives and capacities of the reporters. Examples of typical incentives in international environmental management include normative goals, public images, sanctions and political rewards. Although the observations by Ardron et al. (2018) criticize the ISA's incentives as not being transparent, practical methodologies to increase transparency such as giving contractors more incentives could be addressed and suggested to the ISA.

Under the ISA monitoring regime, the economic value of the information submitted by nations and contractors, such as proprietary data, shall be protected (Lodge et al., 2014). Under ISA most results of reports and reviews or data are not available to anyone except the ISA Secretariat and its Review commission members.

A feeling of fairness and legitimacy is one of the important factors to effectiveness of international environmental regimes (Young, 2011), but is largely lacking in the ISA regime because of the confidentiality practices and other requirements. Although there is a fundamental dilemma between transparency and protection of proprietary information, some policy improvements could bring a more effective system, which may provide mutual benefits for all parties.

Although Hannington et al. (2017) suggest that EEZ mining is easier to monitor, offshore oil and gas practices in the domestic EEZs have shown transparency issues can be addressed in national as well as international waters. For example, the governments of the US[2], Canada, the UK, and Australia have not disclosed the exact location data in longitude and latitude of oil spills occurring in their EEZs through websites (Fraser, Ellis, and Hussain, 2008). Building public awareness, engagement, and best practices can not achieved without that information. Information sharing at the public level might be extremely difficult in the ISA regime too since it deals with business secrets from each mining contractor, and effective monitoring system might be considered as a lower priority.

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[2] The current US system provides the information of the lease, area and rig where an oil spill occurred by the government. https://www.bsee.gov/stats-facts/offshore-incident-statistics.

1.4. Research objectives

My thesis focuses on the ISA's environmental monitoring system for impacts of the deep seabed mining with an emphasis to improve transparency issues that have been pointed out by the earlier studies and to increase the effectiveness of monitoring. The definition of monitoring in this study is not limited only to the technical methods to monitor environmental targets at sea, but also includes a holistic information system to observe, evaluate, and verify the environmental impacts of a regime's human activities. The geographical focus of this thesis is the Clarion Clipperton Zone of the Central Pacific Ocean, where the largest number of the ISA contracted areas of polymetallic nodules exists (16 contractors; Fig. 1.1).

I will explore 1) how monitoring is framed in the current draft ISA regulations and 2) the monitoring approaches and characteristics employed in other practices at the international and national levels. Then I will examine 3) what would constitute the environmental monitoring system that is transparent and effective for ISA mining based on a comparison between the ISA and other monitoring practices. Finally, I will 4) make policy recommendations for ISA monitoring and provide concluding remarks.

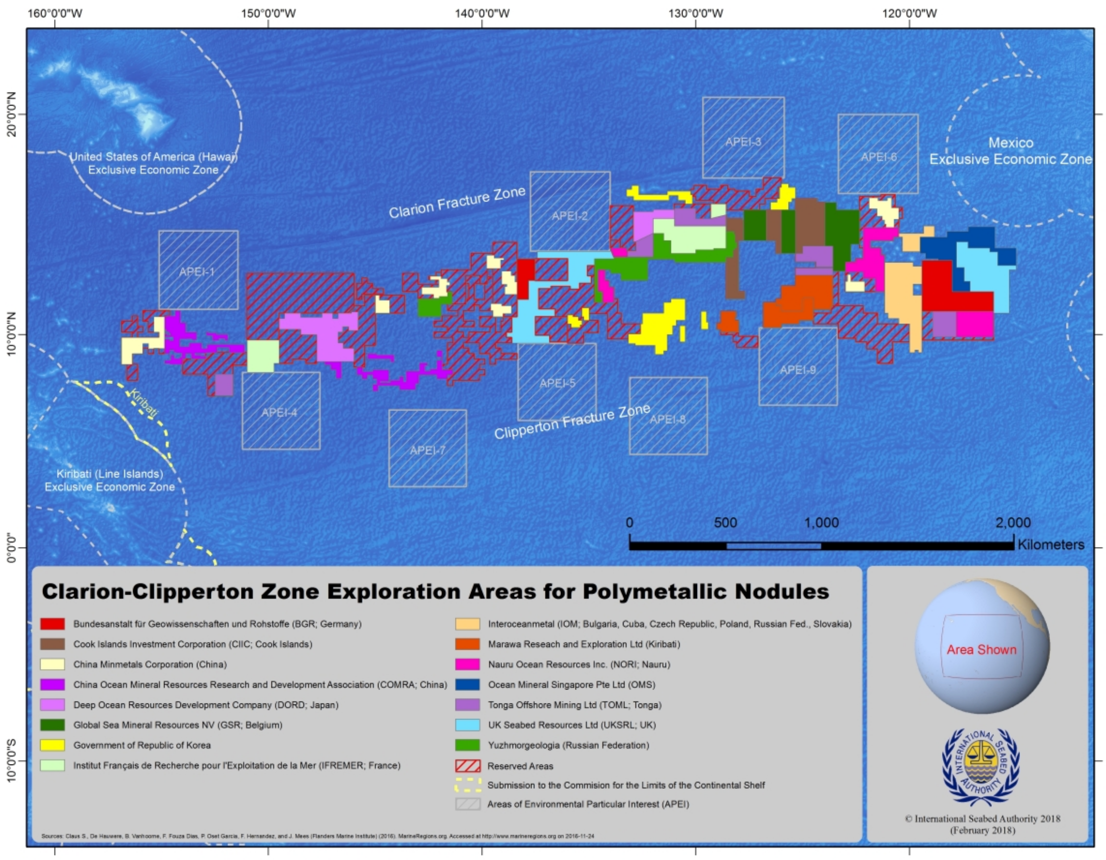

Figure 1.1. International Seabed Authority (ISA) polymetallic nodules contracted areas in the Clarion Clipperton Zone of the Central Pacific Ocean. The figure is cited from ISA website (2018).

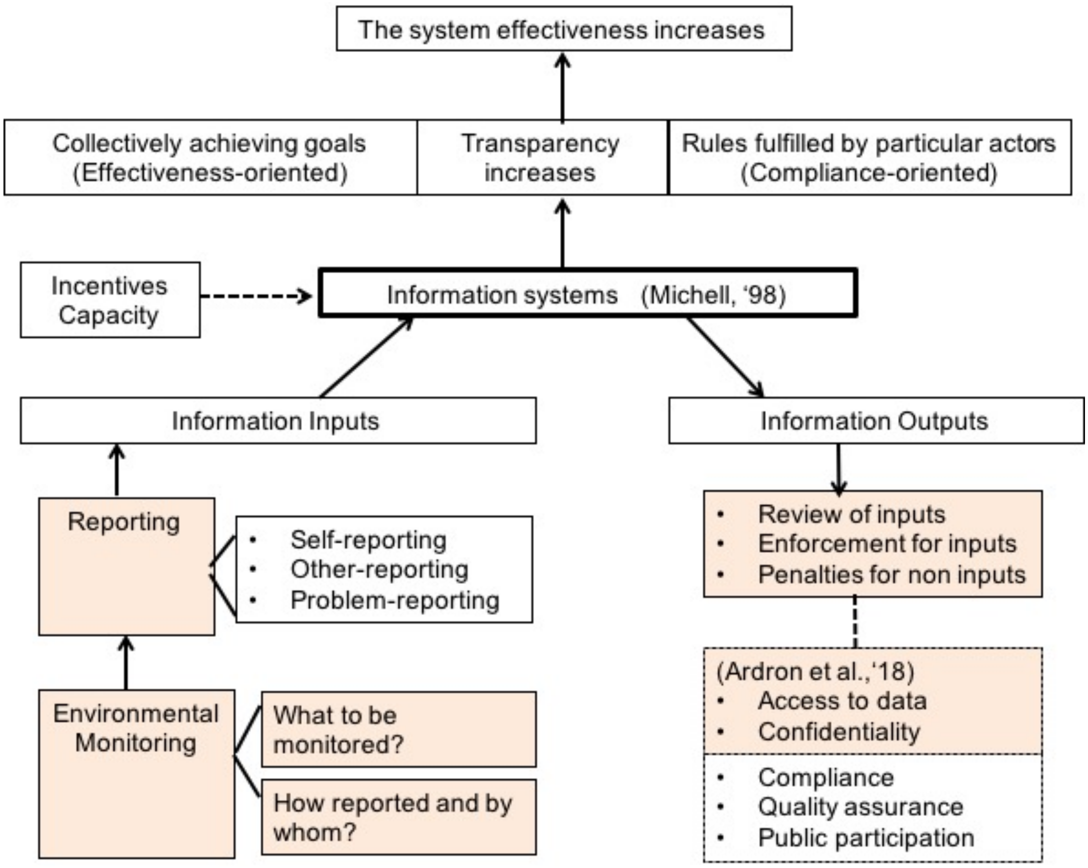

Figure 1.2. A flow pattern of information system to increase transparency and effectiveness sources in the environmental monitoring system. Shade indicates the monitoring elements which this thesis examined.

Chapter 2. Research design

2.1. Characteristics of Deep Sea Monitoring Cases

This study employed a qualitative approach to conduct a descriptive typology analysis to discern options for design of an ideal environmental monitoring system for deep seabed mining for polymetallic nodules. Because deep seabed mining has not yet started, the current discussion of regulations for environmental monitoring at the ISA has many uncertainties. The available data on ISA are limited to the published literature and official reports of the ISA. This study adopted a multiple case study approach to allow an in-depth examination of selected deep sea environmental monitoring cases, to allow consideration of a range of possible monitoring policy options. This study intends to make practical recommendations to the ISA for design of deep seabed environmental monitoring.

To answer the research questions mentioned in Chapter 1, the following characteristics of existing monitoring systems for environmental impacts by marine resource developments are examined: 1. what is monitored, 2. what is reported by whom, 3. how reports and data are reviewed, 4. enforcement of non compliance with monitoring requirements, 5. penalties, 6. access to data, and 7. confidentiality of information.

The analysis is made using the following steps. First, the ISA's environmental regulations and reports are analyzed to examine the characteristics of the existing regime. Second, the key monitoring characteristics above were examined from six cases of seabed environmental monitoring systems. Finally the best options to be adopted for the ISA monitoring systems are discussed.

For the analysis of the ISA system, I examined its proposed regulations and recommendations based on reports from the ISA Council, Assembly and various workshops regarding monitoring systems. Stakeholder responses to general and specific questions to the draft regulations (ISA, 2018a) were analyzed to assess the stakeholders' potential response to toward the design of ISA future monitoring system for the exploitation stage of marine mining.

2.2. Selection of case studies

To obtain information on the characteristics of seabed monitoring systems, four international and two national environmental regimes which monitor offshore and open ocean areas were selected. Case studies were chose using the criteria that it should be: large in scale; having a deep sea component; representative of a large national or international system; and designed for monitoring of extractive industry with environmental impacts. Each of the case studies has unique characteristics that provide information and useful options to compare and contrast with the current ISA monitoring for exploration and discussion of exploitation stage monitoring. These characteristics are described for each case: the Barcelona Convention, the Oslo Paris Convention (OSPAR), the Food and Agriculture Organization (FAO) of the UN global and regional fishery management organizations, the Commission for the Conservation of Antarctic Marine Living Resources, the US monitoring system for deep sea hydrocarbon production, and the Papua New Guinea government monitoring system for mining mineral crusts.

The Barcelona Convention was established by the UN Environment Programme (UNEP) as the Mediterranean Action Plan of the first regional seas program in 1975, and adopted as the Action Plan for the Protection of the Marine Environment and the Sustainable Development of the Coastal Areas of the Mediterranean in 1995 (European Commission, n.d.). The Convention has seven protocols, one of which is for the offshore environmental management. A large part of the convention area within the Mediterranean Sea is defined as international waters, where the density of human activities and sea-lanes is quite high. The multi-national characteristics of this convention area are similar to those for the ISA area, and the area covered by the Convention contains the high-sea area of the Mediterranean Sea. Official documents were obtained from the websites of the Barcelona Convention, which are managed by the UNEP Mediterranean Action Plan (UNEP MAP, n.d.).

The Convention for the Protection of the Marine Environment of the North-East Atlantic, so-called Oslo and Paris Convention (OSPAR Convention) is another large environmental regional management entity for the North Atlantic Ocean and its high-seas area. One of the annexes of the convention is titled as for the prevention and elimination of pollution from offshore sources. The countries signatory to OSPAR utilize two types of monitoring frameworks, the Joint Assessment and Monitoring Programme and the Coordinated Environmental Monitoring Programme. These programs compare favorably with the ISA monitoring program needs. Official documents were obtained from the OSPAR Secretariat ("OSPAR Commission | Protecting and Conserving the North-East Atlantic and its Resources," n.d.).

Global and regional fisheries management organizations of the Food and Agriculture Organization of the UN (FAO) and the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) were examined. They deal with similar jurisdictional settings with respect to high-seas management, and they have been seeking for useful monitoring systems for high impact activities to the environment such as fishing especially to detect illegal, unregulated and unreported fishing. The system needs overarching characteristics, some of which could be applied to deep seabed mining. CCAMLR has the longest history to conduct deep sea fisheries monitoring. Official documents were obtained from the websites of each secretariat (FAO, n.d.-b; CCAMLR, n.d.-b).

The US government offshore oil and gas drilling monitoring was chosen because it is one of the world largest offshore drilling nations with experience with deep sea oil and gas production. Since its first offshore oil production off California in 1896 (American Oil and Gas History Society, 2017), the US government has accumulated the best available technologies (BSEE, n.d.-a). Those technologies might be applicable to the deep seabed mining in the Area as well. Due to the Deepwater Horizon accident within the Gulf of Mexico in 2010, the US government has been revising the management regulations, from which practical lessons can be obtained. Official documents concerning monitoring requirements are obtained from the websites of control and supervisory agencies such as the Department of the Interior, Environmental Protection Agency, US Coast Guard, etc. (BOEM, 2017; BSEE, 2016b; USCG, n.d.).

Deep sea mineral mining project by Papua New Guinea was chosen because it is the first nation to prepare EIAs and monitoring protocols for commercial mining in the UNCLOS era and probably the nation closest to starting commercial deep sea mineral mining in its EEZ. It published an EI statement in 2008 and it is considered to be planning to start a commercial mining within a few years using a Canadian contractor Nautilus Minerals Inc. Some experts evaluate the PNG produced EIA highly and point out that Nautilus Minerals Inc. applied the best available sciences and practices at that time. Official documents were from the websites of the Nautilus Minerals Inc., a Canadian mining company and a sole contractor of this mining project (Nautilus Minerals Inc., n.d.)

Chapter 3. Overview of ISA exploration and exploitation regulations

3.1. Exploration monitoring

The UN Convention on the Law of the Sea (UNCLOS) articulates a basic framework for the ISA to manage deep seabed mining in the Area. In UNCLOS, member states are responsible for monitoring of the effects of pollution caused by their activities in order to protect marine environments (UNCLOS Article 204).

> *UNCLOS*
> *PART XII PROTECTION AND PRESERVATION OF THE MARINE ENVIRONMENT*
> *Article 204 Monitoring of the risks or effects of pollution*
> *1. States shall, consistent with the rights of other States, endeavor, as far as practicable, directly or through the competent international organizations, to observe, measure, evaluate and analyze, by recognized scientific methods, the risks or effects of pollution of the marine environment.*
> *2. In particular, States shall keep under surveillance the effects of any activities which they permit or in which they engage in order to determine whether these activities are likely to pollute the marine environment.*

In the ISA regulatory framework of polymetallic nodules mining, the ISA's executive body, the Council (Fig. 3.1), adopted and amended regulations for prospecting and exploration in 2013 (ISA, 2013b; hereafter called exploration regulations). "Prospecting" means a search for mineral deposits without any exclusive right. "Exploration" means a search for minerals within the contractor's exclusive right. Each contractor is permitted a maximum 150,000 km^2 area at for a period of fifteen years (Fig. 3.2). The exploration regulations define detailed procedures of the contractor's application for exploration. Ultimately, a contracted area has to be divided into two areas half the size of the original area. Each half must have the same resource value. The area-is called a "Reserved Area", and only developing states can be a sponsor of the contractor who applies for exploration/ exploitations in the area (Reg. 17). The other half of the area is retained to be developed by the contracting state. Contractors sponsored by the developing states of China, Singapore, Nauru and Kiribati, for example, made contracts with the ISA using those regulations (Jaeckel et al., 2016). Thus, the Reserved Area system facilitates the willingness of developing nations to engage in mining contracts. Before shifting to an exploitation contract, contractors can twice request for an extension of the exploration contract as Japan and China extended theirs.

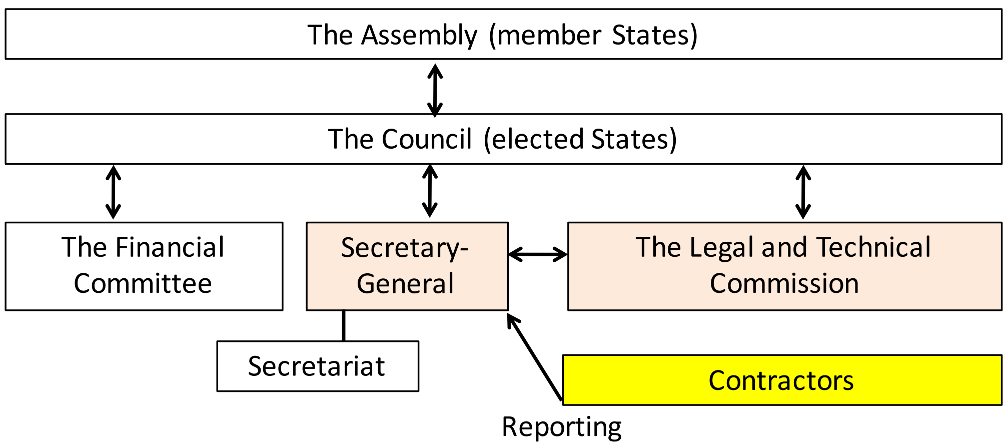

Figure 3.1. ISA organization chart (ISA website, 2018).

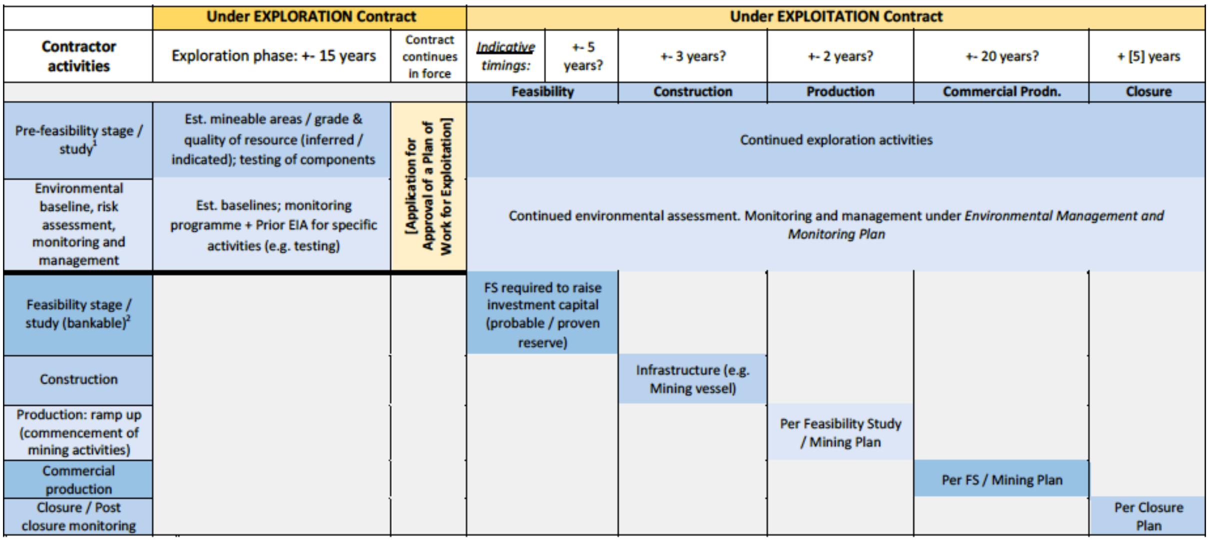

Figure 3.2. Overview of contractor activities for polymetallic nodules mining in exploration and exploitation periods. The figure is cited from ISA (2018a).

Initial application of a Plan of Work and monitoring based on the plan

There are two monitoring systems in the exploration period. One is through the monitoring of contractors' status of their activities, measures taken and accomplishments with the regulations and guidelines. According to the exploration regulations, an initial approval and periodical reporting and review cycle of "Plans of Work" functions as this monitoring system (ISA, 2013b) (Fig. 3.2; Table 3.1).

To start exploration, contractors need to submit to the Secretary-General a Plan of Work which defines a plan for baseline surveys to get an approval by the ISA. As a legal obligation, the ISA shall monitor the compliance with the Plans of Work (Agreement Part XI of UNCLOS), and the Secretary-General and contractors shall jointly review the implementation of the Plan of Work every five years (Reg. 28) (ISA, 2013b). Therefore, technically, contractors have to monitor the compliance as well as other data.

> *AGREEMENT RELATING TO THE IMPLEMENTATION OF PART XI OF UNCLOS Annex 1 (5) Between the entry into force of the Convention and the approval of the first plan of work for exploitation, the Authority shall concentrate on: (c) Monitoring of compliance with plans of work for exploration approved in the form of contracts*

However, the compliance monitoring system is weak because the exploration regulations do not state the compliance monitoring requirement (Table 3.1). There is no special committee to inspect contractors' compliance status in the ISA since a review of the contractors' Plan of Work is basically conducted by contractors themselves and the Secretary General (Table 3.1). Moreover, an instrument to enforce against non-compliance is lacking. Even though the Secretary-General has an obligation to report on the periodical review of a Plan of Work to the Council, currently non-compliant contractors there does not seem to be enforcement followed by punishment or sanction. For example, cases of non-compliance were vaguely reported to exist by the LTC Chair's report in the ISA 23rd annual meeting in 2017;

> *"... there were some cases of non-compliance, which were noted. One contractor submitted two annual reports late. Another contractor did not meet its reporting requirement regarding environmental data and generally failed to comply with requirements prescribed under the standard clauses of the contract..." (ISBA/23/C/13[3])*

But no penalties were assessed (ISBA/23/C/13; ISBA/24/C/4[4]). For these reasons, the current exploration monitoring system does not function well, which lowers ISA's transparency.

[3] The ISA Council meeting report in 2017, 'Report of the Chair of the Legal and Technical Commission on the work of the Commission at its session in 2017'.

[4] The ISA Council meeting report in 2018, 'Information relating to compliance by contractors with plans of work for exploration, Report of the Secretary-General'.

Therefore, institutional improvements are needed (Ardron et al. 2016; Ardron, Ruhl, and Jones 2018).

Annual environmental monitoring of baseline and test mining

The other monitoring system is general "environmental monitoring" by measuring, assessing and reporting of the deep seabed environments through the entire process of baseline surveys to impact assessments from test mining (Fig. 3.2). The exploration regulations define a contractors' obligation to conduct environmental baseline monitoring in order to ensure effective protection for the marine environment from harmful effects (Reg. 32). While conducting those surveys, contractors have to take into account recommendations for environmental aspects issued by the Council. So far, the Council has issued two sets of recommendations for the guidance on possible environmental impacts from contractors' activities and on formatting annual reports (ISA, 2013a, 2015), and developed an environmental management plan for the Clarion Clipperton Zone (ISA, 2011).

These recommendations were previously reviewed by the Legal and Technical Commission (LTC), one of two advisory and working bodies to the Council (Fig. 3.1). LTC possesses a legal obligation to make recommendations to the Council in the development of regulations (UNCLOS Article 165).

> *UNCLOS*
> *PART XI THE AREA*
> *Article 165 The Legal and Technical Commission*
> *2 (h) The Commission shall make recommendations to the Council regarding the establishment of a <u>monitoring programme</u> to observe, measure, evaluate and analyze, by recognized scientific methods, on a regular basis, the risks or effects of pollution of the marine environment resulting from activities in the Area, ensure that existing regulations are adequate and are complied with and coordinate the implementation of the monitoring programme approved by the Council.*

LTC holds substantial executive power in the ISA's regulatory system through requesting, examining and reviewing of regulations and contractors' applications and reports under the Council, however, the LTC does not open information on what they discuss and how they conclude nor they do not allow observers. So far, only summary reports of the LTC's chair have been provided to the Council upon the Secretary-General's obligation (Rule 21; Rules of procedure of the Legal and Technical Commission). Such management characteristics of LTC give an impression to stakeholders that the ISA system has an unclear decision-making process, which is regarded as a huge transparency issue in terms of access to data or review elements (Ardron et al., 2018; Jaeckel et al., 2016; Wood, 1999).

Baseline monitoring requirements for environmental monitoring by contractors are categorized into seven science fields of physical oceanography, geology, chemical oceanography, sediment properties, biological communities, bioturbation, and sedimentation (ISA, 2013a; see Table 3.1 and Chapter 3.3). The ISA published a template of environmental and geological data items to be submitted in annual reports ("Reporting Templates | International Seabed Authority," n.d.), and currently it is presumed that each contractor measures the baseline along this template, and summarizes and reports the data. For example, metallic ions such as Mn, Zn, Cd, Pb, Cu and Hg are recommended to submit for the chemical oceanographic data category, and contractors are asked to refer to the ISA's standardization measurement methods in ISA (2002).

Impact monitoring is required for the contractors' specific activities which need an EIA prior to the exploitation period such as sampling to test if activities exceed limit amount of certain substances, test mining, drilling activities using on-board rigs (ISA, 2013a) (Table 3.1). The monitoring requirements are briefly described in the ISA regulations such as the specific monitoring data on the sediment condition and the chemical and physical characteristics of discharged water are required as well as use of the best available technology. Without any specification of environmental and methodological standards, the selection of methods and items would be difficult.

Contractors are required to report those environmental data annually to the ISA, however, the exploration do not stipulate how the authority review the annual reports (Table 3.1). It is assumed that LTC and the Secretary General review from the past ISA meeting report, but the system is quite ambiguous. Even if LTC reviews annual reports, only one committee system to review and evaluate the whole environmental data and impact assessments would not be sufficient without any significant standards.

Due to the lack of agreed environmental standards and monitoring methods, questions arise as how well contractors actually monitor and report on the environmental impacts of their exploration activities Similarly there are concerns about how reports are reviewed and evaluated, i.e., whether this is done consistently and reliably. Most deep sea biologists are of the opinion that (Van Dover et al., 2017, 2018), it is doubtful the ISA system is adequate. It is difficult ex post to increase deep sea data to resolve the uncertainties, however, it should be still possible to make the review process, at least, clearer for stakeholders through changes in the institutional arrangements for reporting and review.

In confidentiality provisions (Reg. 8, 36, 37), any data other than those related to the protection and preservation of the marine environment can be closed, and only the Secretary-General has a decision-making power to release the information upon a prospector's request to disclose data. This might be convenient for contractors, because they can protect the data related to business secrets such as mineral resource value that might affect investment in contractors' mining business.

However, from a perspective of environmental protection, this system is considered to hide the reports and data which should be transparent. In actuality no annual reports or environmental data have been disclosed as of yet. Although the ISA is planning to release a database system open to public, the criteria for the environmental data are yet to be determined. Moreover, less disclosure lowers the reliability and accountability of reports itself to interested parties.

With respect to exploration and exploitation, the environmental management plan for the Clarion Clipperton Zone is introduced to facilitate regional monitoring effort by contractors, and a zoning survey and monitoring mechanism in each contracted area based on the principle of the protection and preservation of the marine environment (ISA, 2011). Outside the contracted areas, nine areas of particular environmental interest (APEI) have been designated by the ISA so far which shall be permanently preserved as reference areas (ISA, 2011). Within a contracted area, contractors shall create preservation reference zones and impact reference zones in order to monitor the environmental impacts in both zones. Contractors are recommended to co-operate with each other for monitoring, and any coorperation mechanisms should be developed as needed.

Summary on exploration monitoring

There are two sets existing in terms of what is monitored for contractors: one is their activities, measures and achievement based on their Plan of Work, the other is general baseline and test mining environmental monitoring. The Plan of Work is supposed to have characteristics of compliance monitoring, however, the regulations do not stipulate that requirement clearly. The large part of their reporting system relies on more science data templates as requirements and lacks a function of compliance reporting. The review system, especially periodical review of a Plan of Work are conducted only between the Secretary General and contractors, which is not transparent. Due to this non-transparent system, it is not clear that any enforcement and penalties have been actually working to non compliance issue. Considering the current ISA status that any environmental data have not been available, even though it is against the regulations.

Table 3.1. Characteristics of the monitoring system for ISA prospecting and exploration.
SG: the Secretary-General, LTC: the Legal and Technical Commission, EIA: environmental impact assessment, CCZ: Clarion-Clipperton Zone in the Central Pacific Ocean.

Elements	Policy	Instruments	Mechanisms	Pros	Cons
Reporting & Review	Plan of Work	Submission and periodic review of a Plan of Work	Contactors submit a Plan of Work supervised by sponsoring nations. The SG comments, the LTC reviews, the Council makes recommendations (R.20-22). Contractors and the SG do a review of the implementation in the Exploration Plan of Work every 5 years (R.28).	Contractors' plans and review reports by the LTC are published except for confidential information.	Confidential information is protected for contractors. There is no compliance review and enforcement. For every year reviews, there is no review system inside ISA.
	Annual reporting on the environment	Annual reports (Prospecting, Exploration)	Contractors submit annual reports to the SG supervised by sponsoring states on environmental information for baseline survey, monitoring programme and impact assessments by test-mining (Exploration; R.Annex IV); on the prospecting status and compliance (Prospecting; R.6). The SG transmits the contractors' reports on baseline and monitoring to the Council, and the Council makes recommendations (R.32). Contractors' environmental studies will be reviewed by the LTC periodically (2013 Guidelines).	Some guidelines and templates are prepared (2015 Annual report Guideline; 2013 Guideline for EIA; 2008 Recommended measurement protocols).	Reports and review results are not necessarily published in the current regulation conditions. Confidential information is protected. There is no compliance review and enforcement. No standards and standardized methods for monitoring items to be submitted. Surprisingly, reporting on compliance is not considered to matter. The Exploration regulations do not request the compliance reporting during exploration period and do not have any explanation in the guidelines.

What's monitored	Reporting requirements	Annual reports (Baseline, EIA)	Environmental baseline --- Objectives; equipment and methodologies; Interpretation of the findings; 7 baseline categories of data on physical oceanography, geology, chemical oceanography, sediment properties, biological communities, bioturbation, and sedimentation (2013, 2015 Guidelines). EIA -- Information on impacts of exploration and test-mining activities; Goals of 5 year activities; Examination of recovery time of seabed communities; Advantages and disadvantages of different sampling and methods; Statement that activities have not caused serious harm and its evidence (2013, 2015 Guidelines).	Some guidelines for methodologies and reporting templates are prepared (2015 Annual report Guideline; 2013 Guideline for EIA; 2008 Recommended measurement protocols). Large freedom for contractors.	No standards and goals. The regulations focus on contractors' sampling and data submissions, however, one of the most important parts is the analysis and interpretation of those data, which is inevitable for the adaptive management too.
	Measures	Measures	Prospectors and contractors take all necessary measures to prevent, reduce and control pollution and other hazards to the marine environment (R.5; R.Annex IV). Environmental management plans with specific measures that will maximize the potential for the recovery of biota impacted by the contractor's activities in the CCZ (2011 Guideline.41).	Contractors set those measures in accordance with their own national regulatory systems.	No definition on measures. There is no expertise to assess measures. Creation and assessment of all measures are turned into contractor's efforts. There is no revise and review system of those measures in ISA.

	Environmental Management Plan for CCZ	Protected areas; Zoning	Impact and Preservation Reference Zones of contracted areas should be monitored. Environments in the Areas of environmental particular interest (AEPI) should be preserved and monitored. Vulnerable marine ecosystem, ecosystem, habitats, and communities and species should be monitored. Ecosystem-base management should be implemented. The Secretariat manages expert workshops and public database of the environmental information other than confidential information.	Could reduce uncertainties. Could make a science progress and facilitate various collaborations. Encouraged to collaborate among contractors to establish reference zones.	No reporting obligations for contractors. No standards and standardized methods for monitoring items. Most contractors recognize that the identification of reference zones is difficult (2017 Workshop).
Inspection/Enforcement	Onboard and facility inspections	Inspectors	ISA sends inspectors to contractors with a reasonable notice and information of the inspection issued by the SG to monitor compliance and the effects of activities on the marine environment. The SG sends the information from the inspector's report to contractors and sponsoring states (R. Annex IV as a standard clause).	Site visit inspections are one of strong inspection tools.	Notified inspections. Inspection results are not published unless the contractor reports on the annual report (it may become confidential though). Only the SG has the inspection information. High costs. Inspectors' capacity building (ISA)
Enforcement/Penalties	Suspension	The Council order	The Council will suspend or terminate a contract for serious and willful violations of terms of the contract; may impose monetary fine (R.Annex IV)	This would facilitate reporting.	It depends on the fine amount and wealthy nations may be easier.

Access to data	Access to information	Database	The Secretariat set up a working group or an expert consultant group for publicly available and easily accessible databases (2011 CCZ Management plan). All data relating to the protection and preservation of the marine environment should be transmitted to the Secretary-General to be freely available for scientific analysis and research within four years of the completion of a cruise (Transmission of data; 2013 Guideline S.38).	ISA has started running a database project for non-confidential data.	Database project is running, but not yet published.
Confidentiality	Confidentiality		Confidentiality of information is decided and protected by the SG; Other than the marine environmental information; revises every 5 years from the 10th year after the submission (DR.36-37).	Protection of contractors' business secrets.	Definition of confidentiality is ambiguous. Huge power placed on the SG.

3.2. Exploitation monitoring

"Exploitation" contracts are permits for 25 years at a maximum with the contractors having exclusive right. As of present (April 2018), the ISA Secretariat has drafted two sets of regulations for exploitation of Polymetallic nodules: one focuses on the standard contract terms and the other focuses on the environmental management (ISA, 2017a, 2017b). The completion of the development of new regulations is expected by 2019 (ISA, 2018a). Although these regulation drafts will be still revised by the Secretariat taking into account the stakeholder opinions from the ISA workshops, the Council and questionnaires (Appendix A), these are only sources to assess the future ISA monitoring for commercial mining. The regulations are worth examining and taking into account when making my recommendations. Hereafter, the two sets of regulations are referred separately as the exploitation "draft regulations" and "draft environmental regulations" respectively.

Application of exploitation plans and monitoring based on the plans

As well as exploration, the exploitation monitoring is divided into two parts: the initial application for an exploitation contract and the later required regular reporting during mining activities (Table 3.2). The initial application process is necessary to obtain a permission to conduct an EIA and the subsequent exploitation contract. In the first application, contractors submit an Environmental Scoping Report on what they plan to focus in the EIA from test mining (Figs. 3.2, 3.3). In the second application after the Environmental Scoping Report is accepted, contractors submit a Plan of Work. The Plan of Work is a full set of working and environmental management plans. These plans include the Environmental Impact Statement, Environmental Management and Monitoring Plan, Closure Plan and is submitted to ISA along with non environmental four other plans (Financial Plan, pre-feasibility studies and administration fees) (Fig. 3.3). It should be noted that contractors conduct this application process still under the Exploration regulations and contract until ISA issues an exploitation contract to the contractors (Fig. 3.2).

For the initial application of a contract, contractors need a large amount of efforts and data to fulfill such requirements to make the plans as anticipated impact assessments and long-term mitigation measures. Considering that deep sea mining has never started, these requirements would not be easily predicted. For example, the Environmental Scoping Report needs to include proposed activities and environmental objectives, methodologies, identification of directly and indirectly impacted areas, anticipated impacts and mitigations, and a baseline report (Table 3.2; Draft Reg. Annex IV; Draft Env.Reg.18). The EIS template is described in the Exploitation draft regulations' Annex V. The statement needs to include the results of the EIA in Environmental Impact Areas for physio-chemical, biological and socio-economic environments in short-term, mid-term and long-term, risk assessment, good industry practices, mitigation measures, international recognized standards, and Environmental indicators (Draft Reg. Annex V; Draft Env.Reg.32). The Environmental Management and Monitoring Plan needs to include an environmental management system, environmental objectives and targets, potential effects, good industry practice, performance assessment of the plan, proposed stations and technologies, and quality control and management standards (Draft Reg. Annex VII). The detailed descriptions and guidelines seem still under development in the Exploitation draft environmental regulations.

The EIS, Monitoring Plan and Closure Plan are subject to a series of review by the Secretary-General, the public so-called "Interested Persons" (Draft Reg.), LTC, and the Council, and the Council adopts a final approval (Table 3.2). This public review process is not included in the Exploration regulations, and in addition, plans and review comments become publicly available. Many of stakeholders evaluate this review system as highly positive, however, they raise questions about the definition of Interested Persons is pointed out very ambiguous (Appendix A) (ISA, 2018a). The draft regulations define Interested Persons as;

> "*a natural or juristic person or an association of persons that, in the opinion of the Authority, is directly affected by the carrying out of Exploitation Activities in the Area or who has relevant information or expertise*" (ISA, 2017a).

Some request expanding the public consultation to everyone while others suggests narrowing it down to those who are directly affected by contractors' activities (Appendix A).

The information reported by contractors will be made publicly available other than confidential information (Draft Reg. 12, 75) similar to those in the Exploration regulations. Contractors and the Secretary-General can define such confidential information, and there is no standards. The confidentiality has a ten year expiration period.

Once a contract is issued, a Plan of Work is periodically reviewed by the Secretary-General and contractors every five-years (Draft Reg. 47). However, the regulations do not stipulate if any other actor such as LTC, the Council or public joins the review or not. If it is closed review between the Secretary-General and contractors, the review outcomes would not seem transparent.

Annual and periodical monitoring of activities and environmental performance

There are two frameworks to monitor contractors' environmental management status during exploitation: annual reporting of activities and data and periodical reporting of environmental performance (Table. 3.2). In the annual reporting, the monitoring and reporting requirements for contractors are the results of activities and data, measures taken, monitoring undertaken, and environmental performance assessments (Reg.37; Draft Env.Reg.77). Especially measures (e.g. mitigation measures from impacts) are considered important. Contractors and sponsoring states have to take all necessary measures to protect the marine environment (Draft Reg.17, 23, 91). It is assumed that contractors and sponsoring states will establish and implement those measures in accordance with their national regulatory framework. However, a problem might arise in that there is no environmental standards to observe the mining impacts in regulations and guidelines in both exploration and exploitation periods. It is quite unclear how contractors and states could establish necessary measures. This uncertainty issue is suggested by a lot of stakeholders including contactors (Appendix A).

The elements of review and access to data contain some concerns as well, since a review method of annual reports is not articulated in the draft regulations. Although all environmental data in these reports are to be published by the ISA due to the Draft regulations in principle, it is still skeptical that ISA will comply with this because ISA have never published data in the exploration period against rules. Similar to the exploration regulations, any data other than environmental data can become confidential, which is determined by the Secretary-General and contractors (Draft Reg. 12). The confidentiality of contractors' information has a ten-year expiration period (Draft Reg. 75), which will be at the middle of contractors' commercial production period, and some contractors are concerned about this expiration period (e.g. JOGMEC; Appendix A).

The other monitoring framework is environmental performance review (Table 3.2). Contractors assess on the environmental objectives, targets and impacts of their plans during exploitation, which is called environmental performance review, in the years of 2nd, 5th and 10th from the beginning of commercial production (Draft Reg.24; Draft Env.Reg.49). This assessment is required to be conducted independently, but it is still contractors' self review, and any further review by the ISA is not articulated in the draft regulations. Though the Secretary-General makes public its findings and recommendations from the contractors' self review reports, the review system is quite weak.

Both the annual report and the environmental performance report do not stipulate what constitutes non compliance by the draft regulations. No explicit compliance review committee exists. This could bring institutional transparency issue. Instead, ISA seems to focus on the implementation of onsite inspections as a monitoring instrument to solve non compliance (Table 3.2). In inspections, after a reasonable notice, ISA can send inspectors to contractors' mining sites or facilities to directly watch and check compliance, data and equipment. There are two steps of reporting: first, the inspectors report to the Secretary-General and the Secretary-General reports to the contractors' sponsoring states to take necessary actions (Draft Reg.85-88). Based on the conditions of non-compliance and breaching rules, the Secretary-General can issue a compliance notice to contractors to suspend or terminate a contract (Draft Reg.89). As penalties, monetary fines and deductions of the Performance guarantee may be imposed to non compliance matters such as failure to make an annual report (Draft Reg.44, Annex). Therefore, the ISA system highly relies on inspections and penalties to enforce contractors to comply with rules, and they give the Secretary-General high power for the enforcement.

In access to data, the draft regulations encourage making publicly available data related to protection and preservation of the marine environment. To accomplish that, states and ISA are recommended to cooperate in information exchanging (Draft Reg.17, 81). Detailed plans are yet specified in the draft regulations.

Summary on exploitation monitoring

The exploitation monitoring replies on the strict evaluation process of the initial application for a contract, contractors' self effort in reporting and review, and onsite inspections and penalties to enforce rules. These instruments are strong but the transparency might become an issue because a large decision making power only place in the Secretary-General. Their review system is weak or not clearly stipulated in the draft regulations, which would bring transparency issues. The policy of free access to the environmental data is well evaluated, however, the actual implementation is still skeptical because of the exploration practices. Currently, the detailed regulations and requirements regarding the environmental plans (Environmental Management and Monitoring Plan, Closure Plan, etc), which will be included in contractors' Plan of Work, have not yet been determined.

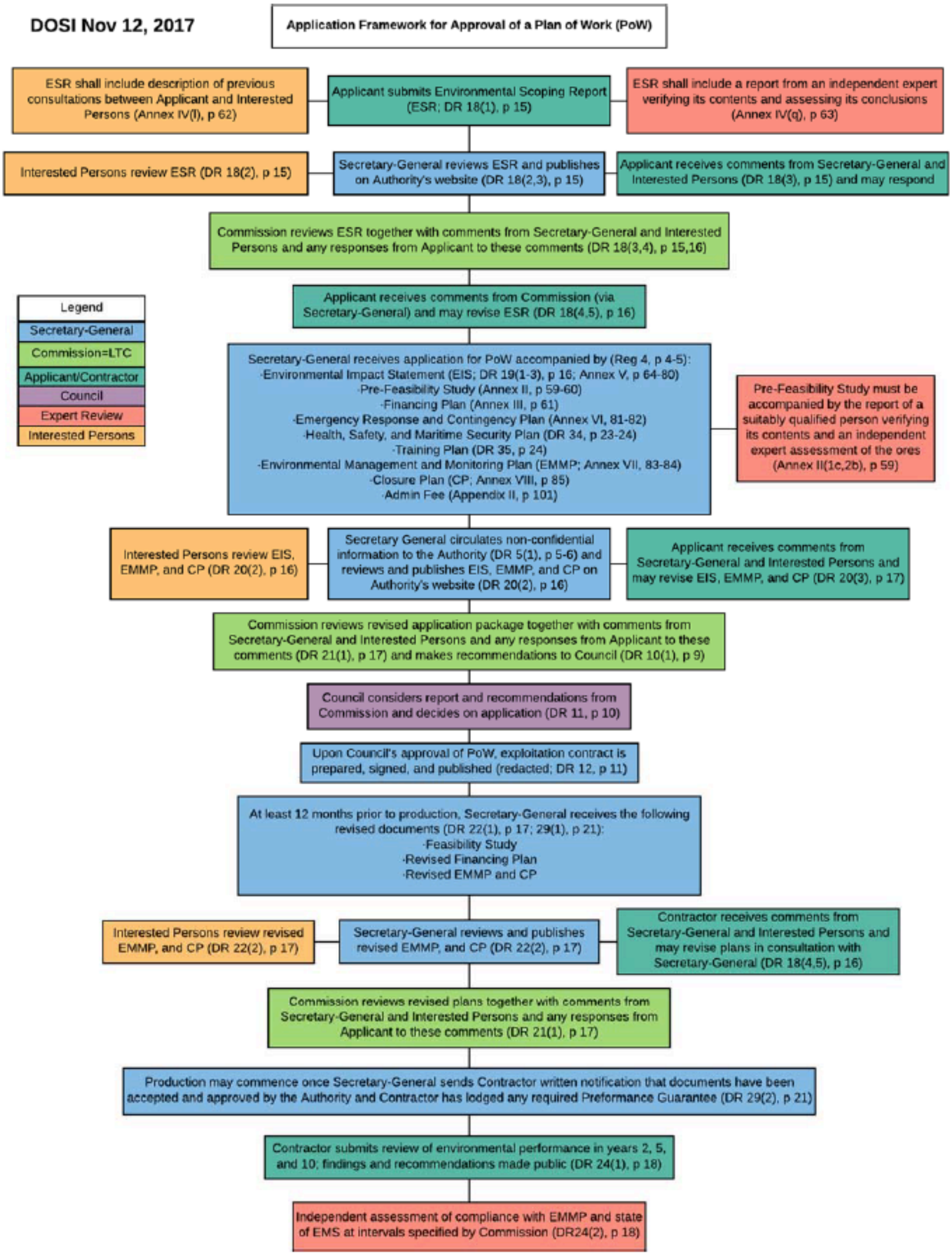

Figure 3.3. Flow chart of the exploitation contract application. The figure is cited from Deep Ocean Stewardship Initiative (2018). ESR stands for Environmental Scoping Report. DR stands for Draft Regulations.

Table. 3.2. Characteristics of the monitoring system for ISA exploitation.
SG: the Secretary-General, LTC: the Legal and Technical Commission, EIA: environmental impact assessment, CCZ: Clarion-Clipperton Zone in the Central Pacific Ocean, DR: draft regulations, DER: draft environmental regulations.

Elements	**Policy**	**Instruments**	**Mechanisms**	**Pros**	**Cons**
Reporting & Review	Initial contract application process	Environmental Scoping Report, Plan of Work, Review by Interested persons, SG, LTC, and ISA.	Contractors submit Environmental Scoping Report for a pre application. The SG and Interested Persons comment, the LTC reviews, and the Council makes recommendations (DR.18). Contractors conduct an EIA, and submit a contract application with a Plan of Work e.g. Environmental Impact Statement (EIS), Environmental Management and Monitoring Plan (EMMP), Closure Plan (CP), etc. The SG and Interested Persons comment, the LTC reviews, the Council makes recommendations. Contractors and the SG do a review of activities in Plans of Work every 5 years (DR.47).	A review system including public consultation. Plans and review report by the LTC are published except for confidential information.	Considering that there is not enough deep seabed mining standards and methods, the review needs very high capacities including high scientific expertise. Is there enough capacity to review reports in the SG, Interested Persons and LTC? Too many uncertainties for requirements in those plans and reports such as Environmental Impact Areas to be assessed. How much review process is opened without observers?
	Annual reporting	Annual reports	Contractors submit annual reports to the SG on the results of activities, measures taken, monitoring taken, and the Environmental performance assessments (Reg.37; DER.77). (See "Mitigation measures" in this table)	Environmental information on Annual reports are published by the ISA.	Regarding Annual report, there is no review system codified. No independent committee or specialized experts to assess compliance. Compliance information is not published?

	Periodical reporting	Environmental Performance report	Contractors conduct an independent assessment of environmental plans and submit Environmental Performance reports (to the ISA?, unclear) in the 2nd, 5th, 10th year from a commercial production (DR.24; DER.49). The assessment is on the environmental objectives and targets, direct and indirect impacts. etc. (DER.49). The SG makes public their findings and recommendations (Reg.24)	Environmental performance review results are made publicly available by the SG.	For Environmental performance review, Contractors conduct the assessment, and it is unclear any father review process inside ISA exists. Even if the contractors use an third party for the review, there is no supervise function to the review. Unless any further guidance makes strict requirements for the review process, the reliability of this review may become low. Also the review interval of Environmental performance is appropriate?

What's monitored/ Methods	Reporting requirements	Plans (ESR, EIS, EMMP)	ESR --- Proposed activities and environmental objectives; methodologies; Identification of Environmental Impact Areas (direct/indirect); Anticipated impacts and mitigations; Baseline report (DR.Annex IV; DER.18) EIS --- Results of the EIA in Environmental Impact Areas (3 parts: physico-chemical, biological, and socio-economic environments in short-term, mid-term and long-term); Risk assessment; Good Industry Practices; Measures; International recognized standards; Environmental indicators (DR.Annex V; DER.32) EMMP --- Environmental management system; Environmental objectives and targets; Potential effects; Good Industry Practice; Performance assessment of the plan; Proposed stations and technologies; Quality control and management standards (DR.Annex.VII)	EIS templates and reporting formats for baseline and EIA and some guidelines exist. Probably new guidelines for monitoring will be prepared. Contractors have a large degree of freedom to choose methods.	There are a number of uncertainties for reporting requirements such as Environmental indicators or Mitigation measures. How can contractors define those before mining starts?
	Mitigation measures		States sponsoring contractors take all necessary measures (DR.91); Contractors take mitigation measures to protect the marine environment (DR.23); ISA, states and contractors implement measures (DR.17)	States and contractors set those measures in accordance with their own national regulatory systems.	There is no expertise to assess measures. Creation and assessment of all measures are turned into state's efforts. There is no revise and review system of those national measures in ISA.

	Strategic Regional Management Plan		Under discussion in the ISA (DER; WS No.17). Monitor defined areas by regulators to create common regional standards and rules before national projects (Jones and Weaver, 2017). In cooperation with other stakeholders.	Could reduce uncertainties. Could make a science progress and facilitate various collaborations.	Unclear collaboration mechanisms and leaderships. Long-term process causes less investments (contractors). High costs for other's areas (who pays?).
Enforcement /Inspection	Onboard inspections		ISA sends inspectors to contractors with a reasonable notice and information of the inspection issued by the SG to monitor compliance, data, equipment, etc. Inspectors make an inspection report and the SG sends necessary information based on the report to sponsoring states (DR.85-88).	Site visit inspections are one of strong inspection tools.	Notified inspections. Inspection results are not published unless the contractor reports on the annual report and the SG made it publicly available (maybe confidential). The SG has only inspection result information. High costs. Inspectors' capacity building (ISA)
Enforcement	Compliance notice	Compliance notice	The SG issues a compliance notice to a contractor if it breaches rules of ISA. If contractors fail to implement measures upon a compliance notice, the Authority may suspend or terminate a contract (DR.89).	Strong power to stop the harmful activities.	The capacity to define if the breaching rules and what rules to be applied. The SG has only the decision making power.
Penalties	Financial deposit	Environmental performance guarantee	Contractors deposits Environmental performance guarantee (DER.44; under construction)	Contractors would be conservative for harmful activities to the environment.	This may be a huge burden for contractors, especially developing nations. This could be really effective for the environmental protection? How to evaluate environmental value? How to evaluate contractors' activities? Wealthy nations may be easier.

Penalties	Monetary fine	Annual report fine	Fine for failure of the annual report submission (Appendix in DR but under construction)	This would facilitate reporting.	It depends on the fine amount and wealthy nations may be easier.
Access to data	Access to information	Cooperation	Access to data and information relating to the protection and preservation of the Marine Environment is encouraged (DR.17). States and ISA cooperate for information exchanging (DR.81).	For science purpose use and transparency improvement.	No cooperation mechanisms.
Confidentiality	Confidentiality		Any information is public other than Confidential Information (DR.12). Confidentiality of information (e.g. economic prejudice or national laws) is decided and protected by the SG; Other than the marine environmental information; 10 years expiration period (DR.75)	Protection of contractors' business secrets.	Definition of confidentiality is ambiguous.

3.3. Technological overview for the environmental management in exploration and exploitation

Some analyzed that ISA is underestimating the preparation of establishing baseline to step into the EIA process (Durden et al, 2018). There should be such sufficient time allowed for the implementation of a baseline survey, i.e., which is seven years assumed by Durden et al. (2018) from the prior experience. When it comes to the environmental measurement technologies, time is an important aspect for the development and selection. Considering the amount of uncertainty amount of the CCZ environment, the ISA exploration contract has a very limited period of fifteen years until commercial mining could be permitted. Does ISA have the ability to select methodologies and technologies in terms of time to efficiently to complete baseline surveys?

3.3.1. Baseline monitoring

As mentioned in Section 3.1, ISA has adopted the recommendations for the measurement methods and technologies of the environmental baseline and impact assessments in 2013 (ISA, 2013a). The recommendations apply for both exploration and exploitation, although new environmental monitoring recommendations should probably be created after the completion of the new exploitation regulations. Baseline surveys need to collect data in seven categories -- physical oceanography, chemical oceanography, sediment properties, sedimentation, geological properties, benthic and pelagic fauna, and bioturbation. These were designed to separate the natural background from the changes by mining activities during and after mining (ISA, 2013a). The target depths for monitoring are divided into three layers -- sea-surface, mid-water, and seabed. The baseline monitoring is a requirement for contractors to continue even once mining starts.

Physical and chemical oceanography

ISA describes the objectives to observe physical and chemical oceanography data are to obtain the behavior of the discharge plume and to collect data prior to any discharge in the water column or at the seabed (Table 3.3). ISA recommends two main observation methods, which are a full-depth profiling and water sampling with the Conductivity-Temperature-Depth (CTD) system from a research vessel and a sensor mooring system for a long term. The CTD system can observe basic physical and chemical property data such as water temperature, salinity, pressure, dissolved oxygen and dissolved nutrients. By the simultaneous water sampling, metals such as zinc, cadmium, lead, copper or mercury and total organic carbon can be measured. ISA has set the minimum list of these chemicals in ISA (2012). ISA also recommends the CTD sampling resolution to be based on international project standards (e.g. the World Ocean Circulatioin Expedition), that is station spacing not exceeding 50 km horizontal resolution with vertical resolution <100 m.

For mooring observation, the attachment of CTD sensors and current meters such as acoustic Doppler current profilers is required to measure water temperature, salinity, pressure and current velocity at 10, 20, 50, 100, 200 m above the seabed. Besides the two methodologies, additional modeling simulations and satellite data are recommended to be taken into account.

The methods and technologies used in the CTD profiling and monitoring systems are conventional and meet the historical international standards for oceanographic research. The EIA guidelines of New Zealand's offshore mining of hydro carbon in the EEZ (NIWA, 2017), which is regarded as a good practice of the adaptive management by Durden et al. (2018) and ISA's draft exploitation regulations, has adopted the same methodologies. However, the ISA's baseline area is much larger than the New Zealand's EEZ and has many unknowns in the environment. For the time efficiency perspectives, a strategy to complete baseline surveys is lacking in the physical and chemical observation categories of ISA recommendations.

First, even the large-scale deep circulation patterns are still unknown in the CCZ. As Figure 3.4 shows, it has been assumed that the deep currents in the CCZ might be upwelling into the upper layer, however, there is not enough data and research to confirm that theory. Also, deep water property gradients are generally diluted compared to surface waters and it makes much harder to figure out current structure. Therefore, well-planned observation and analysis strategies from a larger perspective should be necessary. The ISA contractor's observation in the much smaller contracted area would make it very difficult to reach out to obtain larger circulation patterns, which are very basic and necessary information for the baseline.

Second, the temporal and spatial variation of data would not be enough taken by the mooring requirements because the current mooring requirements seem to be set for a very small-scale area only near the seabed. Deep currents have significant temporal variations from a few days to several months as is shown in Figure 3.5. They could be also affected by inter annual variations such as El Nino and decadal variations by upper layers. For the CCZ, one of the difficulties in the mooring system would be a setting of sensor depths since the depths of the general deep currents are not known well. The deep flow also often changes its path according to temporal variations. Therefore, it is assumed that the ISA-recommended mooring system to measure only within 200 m above the seabed does not explore enough in the CCZ case, and it is a very inefficient way.

Dissolved chemical substances are generally advected by ocean currents too, and the temporal and spatial variations need the same strategies of physical observations.

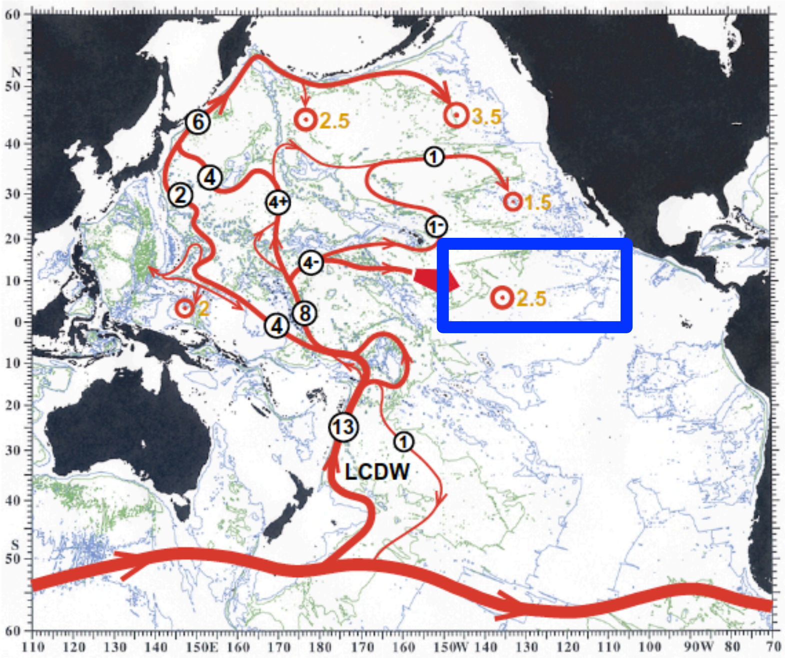

Figure 3.4. Summary of deep circulation pathways above the seabed in the Pacific Ocean. The blue rectangle indicating CCZ, where an upwelling (red dot) is assumed. The figure is cited and modified from Kawabe and Fujio (2010).

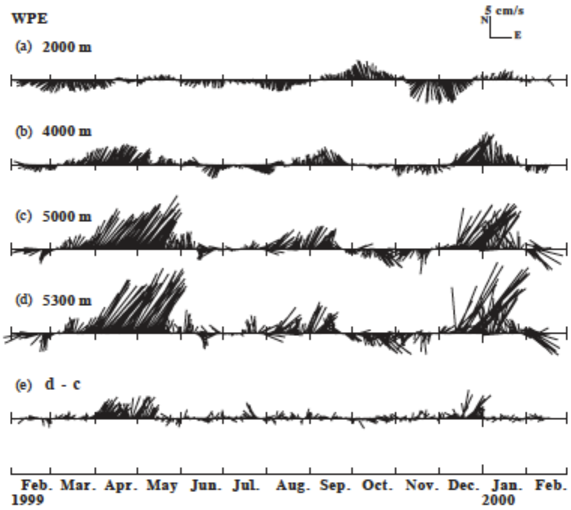

Figure 3.5. An example of temporal variations of deep current vectors measured by a moored current meter system at the Wake Island Passage, 20°N, 170°E. The figure is cited from Kawabe et al.(Kawabe, Yanagimoto, Kitagawa, and Kuroda, 2005).

Sedimentation and sediment properties

ISA recommends to measure sedimentation rates in water column by a sediment trap mooring system to evaluate the effects of the discharge plume (Table 3.3; Figure 3.6). The sediment traps can measure the flux of particulate matters in water column. Monthly resolution is required in order to analyze inter annual or seasonal variations with two layers with one trap set at a depth below 2000 m to catch the flux from the euphotic zone and another at 500 m above the seabed to detect the flux extending out of it. These sediment traps can be set on the current meter moorings for physical oceanography.

ISA also recommends to measure sedimentation rates on the seabed by box or multiple sediment corer systems from a research vessel to predict the behavior of the discharge plume and test-mining effect on sediment and pore water composition. Methodologies for doing these measurements are not described in the recommendations. ISA (2002) recommends to use the best available method due to lack of specification of standards.

For sedimentation rates, Nautilus Minerals Company, which is an ISA contractor of designated by Tonga, published a technical report from its exploration in the CCZ (AMC Consultants Pty Ltd., 2016). Summarizing the earlier literature on the CCZ, they point out that taking into account the natural variation of sinking particle flux it would be challenging to define the incremental variation caused by exploration and mining activities (Radziejewska et al, 2001). For example, ENSO has caused a natural variation of sinking particles up to a three-fold increase against background (TOML report 2016; Kim et al., 2011). ENSO is inter-annual variations forced by the long-term air-sea interactions, and it is suggested the complete understanding of sedimentation baseline should be difficult even by a long-term mooring observation. The sedimentation baseline in the CCZ would also affected by the fine particulate matters naturally produced by hydrothermal vent activities in the East Pacific Rise (Figures 3.7a, 3.7b). The measurement of such a fine particle distribution is difficult with the current mooring and sediment corer techniques. Therefore, the strategy to choose effective mooring points and depths would be important.

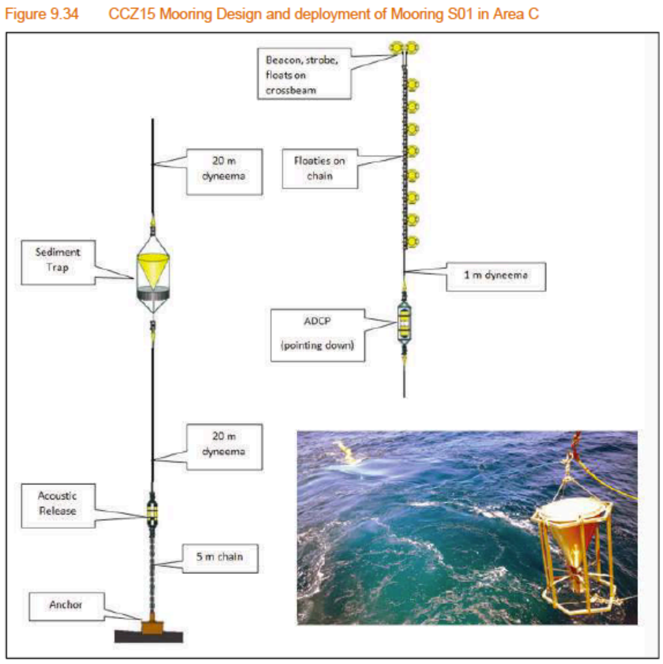

Figure 3.6. A sediment trap mooring system used by Tongan sponsored exploration in the CCZ. The figure is cited from Nautilus Minerals Company (2016).

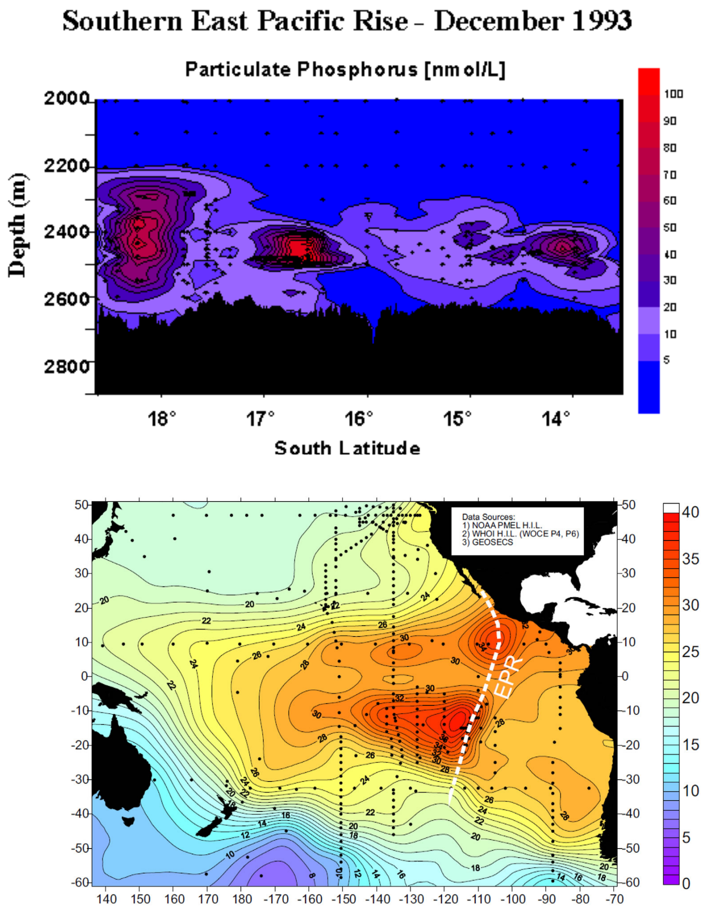

Figure 3.7a,b. Distribution of particulate phosphate produced from hydrothermal activities in the southern East Pacific Rise (a: upper panel), and an example of the lateral distribution of helium, one of such hydrothermal produced substances from the East Pacific Rise (b: lower panel). The figures are cited from (Feely et al., 1996) and (Lupton and Jenkins, 2017).

Benthic and pelagic fauna and bioturbation

The objective of sampling benthic and pelagic fauna is simply to collect data on "natural" communities and the longest set of instruction is given to this category in the 2013 recommendations (ISA, 2013; Table 3.3). Fauna are classified into Megafauna, Macrofauna, Meiofauna, Microfauna, Nodule fauna, and Demersal scavenger. Sampling individuals and characterization by photo/video/gene sequence observation are required in addition to the

GIS habitat mapping and measurements of trace metal and toxic elements in muscle. Sampling points, times and methods are determined as at least annually for three years at minimum prior to test mining in both the Mining Reference Zone and Preservation Reference Zone by multiple or box corer methods at 3-6 sediment layers or by traps mounted on such a platform as Remotely Operated Vehicles (ROVs). Large fauna such as Megafauna and Demersal scavengers are recommended to be monitored by photos on a mooring system for a long-term, 4 or 5 times per day for more than a year.

Bioturbation is observed to meter background "natural" rates of sedimentary processes by the biological process. ISA recommends to sample core profiles of excess Pb-210 activity at least 5 layers per core.

These methodologies are conventional and almost the same such as other practices as the New Zealand offshore mining. However, the ISA's sampling guidance does not examine the spatial resolution well. Taking into account the fact that new benthic species have continuously found in the CCZ area by scientists (New York Times, 2017), the completion of habitat maps covering the large area would be difficult for fifteen years with the current monitoring technologies. The biodiversity issue has been raised in response to expected start of the ISA mining and is now the most controversial topic for stakeholders (Van Dover et al., 2017). ISA should make any specific goals and scopes to know benthic communities and to set a timeline for completion.

Geological properties

The last category, geological properties, is to determine the heterogeneity of the environment and assist the placement of suitable sampling locations (Table 3.3). High resolution and quality bathymetric data by acoustic sonar systems such as multi beam sonars (Fig. 3.8) or echo sounders are required to create regional bathymetry GIS maps, and sampling using sediment corer systems. ISA does not provide much guidance in this category. High resolution geological surveys by sonars are inevitable to find out the basic mineral's distribution and usually conducted in the beginning of the prospecting and exploration periods. International standard methods provided by the International Hydrographic Organization (IHO) have been usually adopted in many nations to determine maritime geographical jurisdiction. In the standards, IHO determines the minimum horizontal resolution as 20m plus 10 % of the water depth. With a smaller frequency sonar mounted on underwater platforms, the resolution can be decrease to a few centimeters. The ISA guideline does not specify the spatial resolution.

Figure 9.12 MBES operations schematic

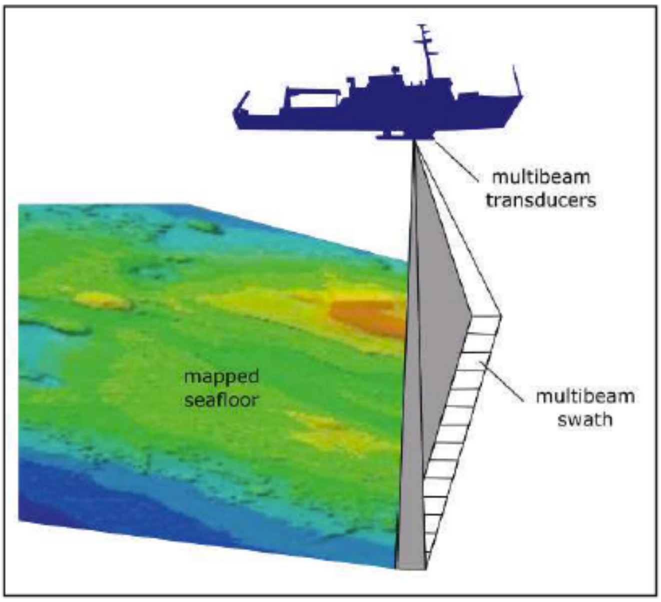

Figure 3.8. A schematic of the multi-beam sonar system to measure bathymetry data. The figure is cited from Nautilus Minerals Company (2016).

Table 3.3. Required items and methods for baseline monitoring.

Categories	Objectives	Items	Requirements	Required Sensors, Platforms (assumed)
Physical Oceanography	To obtain the behaviour of the discharge plume.	CTD system profile data for entire water column. Long-term mooring data of current meters. Satellite data analysis. Modeling	Sampling resolution based on international project's standards. Station spacing not exceeding 50 km. Vertical resolution is <100m.	R/V: CTD system with water sampled calibrations. Mooring system: CTD sensors for mooring, Current meters for mooring (single beam, acoustic Doppler).
Chemical Oceanography	To collect data prior to any discharge in the water column or at the seabed.	Minimum requirement parameter list (ISA, 2002) Water sampling Modeling	At the same locations as Physical oceanography measurements. Vertical and temporal variation. (phosphate, nitrate, nitrite, silicate, carbonate alkalinity, oxygen, zinc, cadmium, lead, copper, mercury, total organic carbon).	R/V: Water sampling by CTD system.
Sedimentation	To model and evaluate the effects of the discharge plume	Mooring of sediment traps.	2 depths (anywhere below 2000 m, 500 m above seabed); traps could be on the same moorings of current meters. Monthly temporal resolution.	Mooring system: Sediment traps.
Sediment properties	To predict the behavior of the discharge plume and test-mining effect on sediment and pour water composition.	Specific gravity, bulk density, shear strength and grain size, the sediment depth of change from oxic to suboxic, or suboxic to oxic, conditions.	Protocols in ISA (2002): best available method (no common standards). Pre test mining sampling.	R/V: Sediment corers (box-, multiple-)
Benthic and pelagic fauna	To collect data on "natural" communities.	Megafauna, Macrofauna, Meiofauna, Microfauna, Nodule fauna, Demersal scavenger. The characterization of pelagic and benthic communities (photo, sampling, gene sequence). GIS mapping of habitat. Trace metals and potential toxic elements in muscle.	Fauna: At least one test-mining site and the preservation reference site prior to the test-mining activity. At 3-6 layers of core sampling for each monitoring point. Photo: 4-5times per day over a year.	R/V: Megafauna (photo, video, sampling), Macrofauna (multi-), Meiofauna (multi-), Microfauna (multi-), Nodule fauna (box-, ROV), Demersal scavenger (photo, video, traps). Mooring system: Megafauna (photo, video), Demersal scavenger (photo, video).
Bioturbation	To meter background "natural" rates of sedimentary processes	Sampling of core profiles of excess Pb-210 activity	At least five levels per core.	R/V: Sediment corers (box-, multiple-)
Geological properties	To determine the heterogeneity of the environment and assist the placement of suitable sampling locations.	High resolution bathymetric data; Heavy metals and trace elements.	GIS regional maps.	R/V: Acoustic sensors; Sediment corers (box-, multiple-)

3.3.2. EIA monitoring

The purpose of the EIA is to obtain the information on the impacts caused during and after exploration and test-mining activities and on the length of time to recovery of seabed communities from disturbance activities on the seafloor (ISA, 2015). Use of the best available technologies and methodologies is recommended (ISA, 2013).

For commercial deep seabed mining of polymetallic nodules, the collecting and lifting system shown in Figure 3.9 shows what the mining industry is expected to construct as a mining system. Nodules on the seafloor are collected by Collector technology, and crushed into smaller parts by Crushing technology, and lifted through a riser pipe onto a vessel by a huge pump system by the way of the riser pipe. On the vessel, the crushed nodules are separated from seawater and shipped to the land processing facility by a transport vessel. Most contractors do not reveal their detailed technologies yet except for some such as Korea (Fig. 3.10).

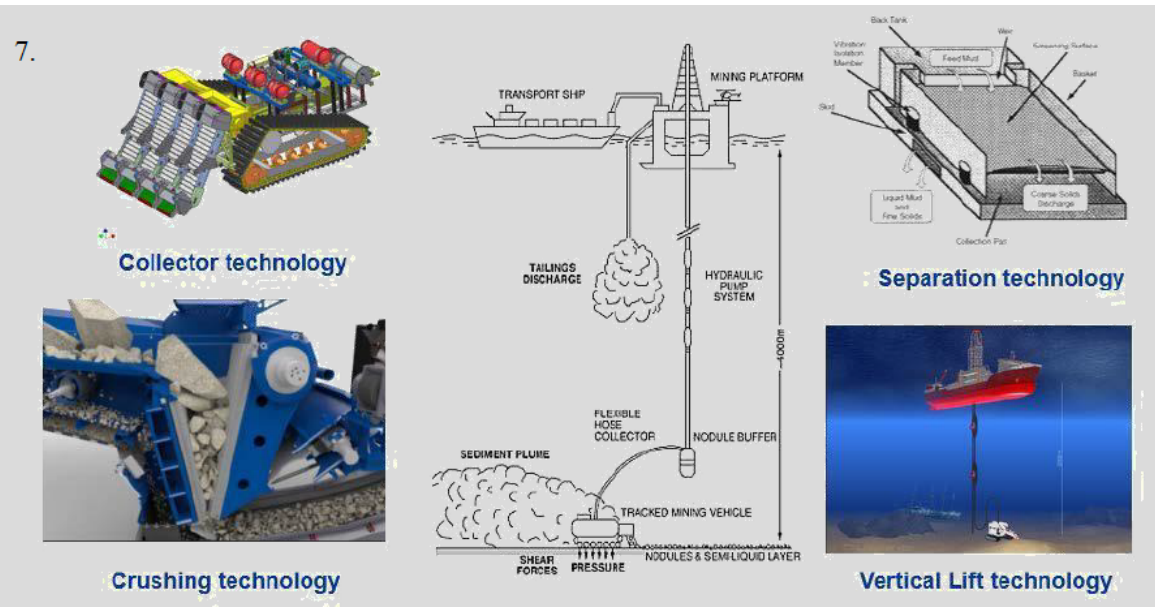

Figure 3.9. A schematic of deep seabed mining and illustrations of mining machines. The figure is cited from Ghosh (2017).

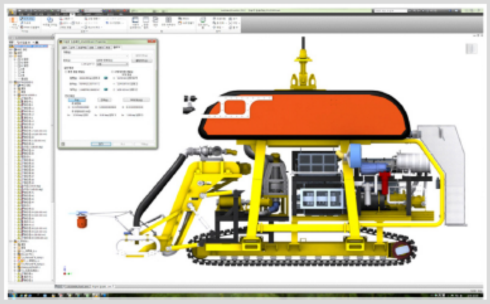

Fig. 2 3D CAD model of MineRo

Table 1 Specifications of MineRo model

MineRo model	
Total mass(in air) [ton]	27.336
Total mass(in water) [ton]	9.381
Contact length of track [m]	4.049
Contact width of track [m]	0.7
Contact area [m^2]	11.336
Contact pressure [kPa]	8.115

Figure 3.10. Korean collector "MineRo" and pump system. The figures are cited from Lee et al. (2014) and Service (KOCIS) (n.d.).

It is suggested that contaminated water plumes would occur at least from the collector and crusher (operational plumes) and from the riser pipe after the nodules are separated to the surface ship (discharge plumes). Also the moving collector and crusher physically change the seafloor, which causes direct impacts to the seabed properties and its fauna. Then, those plumes, their sedimentation to the seabed, and geological changes of the seabed would be very important for the EIA categories. Different from baseline monitoring in a large area, the EIA needs to detect the property changes in a limited spatial volume, plumes in water. Does the ISA have any criteria useful for the plume detection effectively and accurately? How does ISA define those discharge plumes? Do they suggest any temporal and spatial resolutions for technologies to define them? Real-time monitoring or e-monitoring are suggested by the ISA for inspections instead of on-board human inspectors in the regulations, but what kinds of technologies do they apply?

Monitoring during activities

Generally classified, three categories of monitoring data are required during mining activities -- collector locations, sediment production discharge plumes (ISA, 2013; Table 3.4). First, location data are about the width, length and pattern of collector tracks on the seafloor. ISA does not make any instructions on the measurement of locations. These are basic data and usually such a system as the Super-Short-Baseline systems (SSBL) would be applied. SSBL is an acoustic detection system to monitor underwater vehicle's location using a transponder on the vehicle and the ship's sonar and GPS systems.

Second, sediment information is divided into four items -- the extent of physical effect by the collector, the characteristics of collected nodules, sedimentation area and thickness from operational plumes, and collector's qualifications such as volume and size spectra of materials. ISA does not provide technical guidelines for these items either. The third item, plume-induced sedimentation data should be collected by sediment corer systems as well as baseline surveys, however, any resolution criteria should be provided.

Third, for plume information, both operational plume and discharge plume are needed separately. Required information of the operational plume are size, geometry, trajectory and spatial extent of the operational plume relative to the particle sizes. For the discharge plume, volume, concentration, composition of particles, chemical and physical characteristics, behavior of the discharged plume at the surface, in mid-water or at the seabed are required. Unfortunately, ISA does not provide technical instructions for either. The ISA's definition of plume does not suggest any particle size and materials (see the quotation below).

The definition of "Plume" (ISA, 2013)
A dispersion of seawater that contains dense sediment particles. Benthic plume is a stream of water containing suspended particles of sea floor sediment, abraded manganese nodules and macerated benthic biota that emanates from the mining collector as a result of collector disturbance of the sea floor and spreads in a zone close

to the sea floor. The far-field component of the benthic plume is termed the "rain of fines". Surface plume is a stream of water containing suspended particles of sea floor sediment, abraded manganese nodules and macerated benthic biota resulting from the separation, on board the mining ship, of the nodules from the water carrier and spreads in a zone closer than benthic plume to the ocean surface.

While it relates to a different kind of mineral mining the Papua New Guinean mining project of polymetallic sulfides in the EEZ published an environmental impact statement (EIS) report. They conducted measurements of particle size in the seabed and sedimentation simulation from operational plumes relative to particle sizes (Fig. 3.11a,b). They found the unconsolidated sediment particle size varies from the order of 0.0001 mm to 1 mm. They concluded that the finest particle (clay particle ~ order of 0.001 or less) spreads at the largest extent less than 1 km by their test mining operation of 20 months (Fig. 3.11a,b). The above result is a simulation, however, the ISA contractors need to monitor such a spatial distribution relative to sizes using any underwater instruments. Especially, the discharge plumes have to be detected in all layers with additional physical and chemical property measurements without disturbing the mining operation. That would require a monitoring strategy and high technologies and techniques.

Post Mining Monitoring

Six categories of monitoring data are required during activities -- sediment, water characteristics at plume depths, geomorphology, currents, benthic communities, and baseline (Table 3.4). Except for baseline, changes in those monitoring categories by activities are measured in all five categories. For water characteristics, changes in physical and chemical properties at the depths of discharge plumes have to be reported. Benthic communities are further divided into five items in terms of impacts, which are changes in abundance and behavior by sediment smothering, changes in mining areas, changes in adjacent areas, changes in metal contaminations by re-sedimentation, changes by plumes, and changes by currents.

In the 2013 recommendations, ISA gives such suggestions as discharge plumes may change plankton abundance, however, they do not provide further analysis methods and technological instructions. In that sense, the New Zealand's EIA guidelines for offshore mining do not give enough specific technological and analysis methods either, especially on how to detect and describe physical and chemical oceanographic impacts (NIWA, 2017). This indicates a large part of monitoring including its interpretation should be left to contractors' own methodologies and efforts in an EIA in the ISA regime.

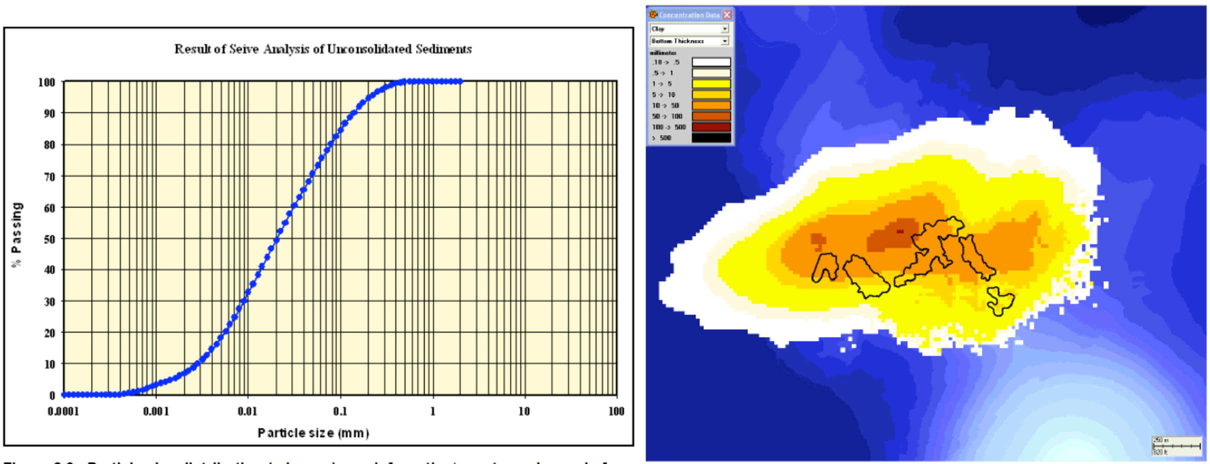

Figure 2.3. Particle size distribution (microns) graph from the 'worst-case' sample from the unconsolidated sediments at the Solwara-1 site.

Figure 3.3a. Sediment bottom thickness for clay particles surrounding the Solwara 1 mining lease area after simulating the full removal and placement operation.

Figure 3.11a, b. Unconsolidated sediment particle sizes (a: left panel) and simulated sedimentation thickness of clay (b: right panel) in the Papua New Guinean mining project EIS. (Coffey Natural Systems, 2008).

Table 3.4. Required items for EIA monitoring.

Categories	Monitoring items during activities	Categories	Monitoring items after activities
Location	Width, length and pattern of the collector tracks on the sea floor	Sediment	Thickness of redeposited sediment and rock rubble over the area affected by the operational plume caused by the mining test activity and by the discharge plume.
Sediment	(1: Physical effect extent) Depth of penetration in the sediment or rock and the lateral disturbance caused by the collector	Water characteristics	Changes in the water characteristics at the level of the discharge plume during the mining test.
		Currents	Changes in water currents.
	(2: Collected nodules) Volume and type of material taken by the collector	Geomorphology	For mineral deposits, post-test-mining maps of the mined area, highlighting changes in geomorphology.
	(3: Sedimentation from plumes) Area and thickness of sedimentation from the operational plume and the distance where sedimentation is negligible	Benthic community	(1: Changes in abundance and behavior by sediment smothering) Abundance and diversity of benthic communities and changes in behavior of key species subjected to smothering by sedimentation
	(4: Collector's qualifications) Ratio of sediment separated from the mineral source by the collector; Volume and size spectra of material rejected by the collector		(2: Changes in mining areas) Changes in the distribution, abundance and diversity of benthic communities in the mining area, including rates of recolonization
			(3: Changes in adjacent areas) Possible changes in the benthic communities in adjacent areas not expected to be perturbed by the activity, including the operational and discharge plumes
Plume	(1: operational plumes) size and geometry of the operational plume at the seabed, trajectory and spatial extent of the operational plume relative to the particle sizes within it.		(4: Changes in metals by resedimentation) Levels of metals found in dominant benthic fauna subjected to resettled sediment from the operational and discharge plumes
	(2: discharge plumes) Volume of discharge plume from the surface vessel, concentration and composition of particles in the discharged water, chemical and physical characteristics of the discharge, behavior of the discharged plume at the surface, in mid-water or at the seabed, as appropriate.		(5: Changes in behavior by plumes) Changes in the behavior of the fauna at and below the discharge plume.
			(6: Changes by currents) The response of organisms to changes in circulation.
		Baselines	Resampling of local environmental baseline data at reference and test zones and evaluation of environmental impacts

Chapter 4. Case studies of deep sea monitoring

This section explores the characteristics of monitoring systems in four international and two national monitoring regimes (i.e. the Barcelona Convention, the Oslo Paris Convention, the Food and Agriculture Organization of the UN, the Comission for the Conservation of Antarctic Marine Living Resources, the US government, and the Papua New Guinea government) and examines which practices should be applicable to the ISA monitoring as the best practices. As mentioned in Chapter 2, the six cases were selected if characterized by large scale, deep sea component, large national or international realm, and monitoring of extractive industry with environmental impacts. As described in Chapter 1 and 2, the important monitoring elements in this thesis are what is monitored, reporting, review, enforcement, penalties, access to data, and confidentiality. I analyze how each monitoring regimes of deep sea addresses the elements is assessed and compare to identify options for ISA to utilize in its development of a monitoring system for deep seabed mining.

4.1. Barcelona Convention (UNEP Mediterranean Action Plan)

The Barcelona Convention was initiated by UNEP and established in 1975 by the Mediterranean nations and European community as a regional seas program aiming at the protection of the marine environment through a regional approach (UNEP MAP, n.d.). Currently there are 22 contracting parties mainly from the Mediterranean coastal region. The Convention has adopted seven protocols, each of which addresses a specific conservation aspect and is implemented by multiple strategies and action plans. "The Protocol for the Protection of the Mediterranean Sea against Pollution Resulting from Exploration and

Exploitation of the Continental Shelf and the Seabed and its Subsoil", the so-called Offshore Protocol, was adopted in 1994 and entered into force in 2011, has been ratified by eight parties so far (Albania, Croatia, Cyprus, Libya, Morocco, Syrian Arab Republic, Tunisia, and EU).

This protocol constitutes a legal framework for the management of environmental impacts caused by the offshore oil and gas development, e.g., EIA Procedure and Contingency Plan (UNEP MAP, 1994). The management target setting seems close to that of the ISA's deep seabed mining regime in terms of geological, industrial and jurisdictional conditions. According to Protocol Article 19, the operators shall conduct monitoring and reporting, and the competent authority of the Contracting Parties shall establish a national monitoring system.

For the Protocol's goals, three monitoring frameworks seem to be applied: compliance monitoring under the Convention, monitoring within the Offshore Protocol, and an overarching monitoring project, the Integrated Monitoring and Assessment Programme (IMAP) (Table 4.1).

First, as for the compliance with the reporting and review system, the Convention stipulates the Contracting parties shall monitor the compliance and effectiveness of measures implemented for each protocol (The Convention Art. 26, 27). Therefore, this system is a legal instrument to examine if a nation has submitted a national report that fulfills requirements of the Offshore Protocol. This legal instrument is considered unique and strong because this regime has adopted a three-tiered reporting system for compliance (UNEPMAP, n.d.). Not only a national report but also reports by any other entities and the Secretariat are taken into account in the compliance assessment. The reports are reviewed primarily by the Contracting

Parties Meeting every two years, but also reviewed by the advisory body, the Compliance Committee. The Compliance Committee system is innovative. It was introduced in 2008, and observers are able to join the Compliance meeting to examine the review (UNEPMAP, n.d.). As for outputs, summary reports on the compliance condition with non-compliance nation's names can been seen online, and the public can request information disclosure to the Secretariat. But, the contracting party's confidentiality is still protected. Therefore, the stricter multi-reporting system provides incentives to Parties for reporting correctly and to observers such as environmental NGOs for participating. Because of these features the compliance monitoring system constitutes a compliance-oriented information source, which can improve the transparency of the monitoring regime.

Actual environmental monitoring is the responsibility of each operator and the government's inspection for the information on installations of offshore facilities, oil spills and discharges, as required by the Offshore Protocol (Table 4.1). The protocol sets the list of the harmful and noxious substances and materials to be prohibited and to be subject to a special permit in the Protocol Annexes I and II.

To implement the protocol effectively, the Contracting Parties adopt Offshore Action Plans (UNEP MAP, 2012; UNEPMAP, 2016a). The Offshore Action Plan aim to establish more regional goals such as common standards and a developing a collaborative approach for environmental impact monitoring as well as implementing the regular national monitoring. Similar to the Compliance monitoring, the system applies the Part's self-reporting standard of every two years, which is based on the Operator's self-monitoring, and the Parties review the reports. The committees of the Offshore Oil and Gas Group and its Sub Groups, comprised of the Parties, support the Action Plans and make a recommendation to the Parties. The implementation of offshore monitoring procedures and program is one of the main objectives of the groups (UNEP MAP, 2016a). For reporting outputs for public consumption, an online regional data system is being developed and every two-years publication is required by the Parties and Secretariat in order to promote access to information (UNEPMAP 2016b). Thus, implementation of the Protocol is still emerging but there is an effort to establish mechanisms to develop more standards and to promote monitoring methods by multiple committees and also regionally. These approaches make the Convention's characteristics into a transparent reporting regime.

The Integrated Monitoring and Assessment Programme (IMAP) aims to establish a national-level integrated monitoring system and facilitate collaborations by the Contracting Parties in overall monitoring topics including from offshore development (Table 4.1). The IMAP was initiated by the Convention Mid-term strategy for 2016-2021. In coordination with other topics, offshore monitoring has such missions as review and updating of national offshore monitoring programs, the establishment of the IMAP common indicators, more regional monitoring by each nation, and common report submission among Parties. Reporting on the IMAP implementation is conducted by the Parties based on the regular reporting. Review is carried out with the Offshore Protocol monitoring review. The common indicators give an indication of the degree of threat or change in the marine ecosystem and can deliver valuable information to decision makers (UNEP MAP, 2017b). Offshore-related indicators are mostly chemical contamination substances and chlorophyll-a and nutrients. For example, Indicator 17 (Concentration of key harmful contaminants measured in the relevant matrix) is subject to the chemical contamination monitoring for the offshore pollution.

In the first meeting of the Offshore Oil and Gas Group Sub Group on the environmental impact in 2017, they proposed to monitor 19 IMAP indicators in the offshore monitoring under the IMAP (UNEP MAP, 2017a). Feasibility studies of some indicators related to biodiversity was only carried out by IMAP for monitoring technologies and financial perspectives, but not for the offshore monitoring's chemical indicators.

To summarize, the offshore monitoring system under the Barcelona Convention has developed the multiple instruments to implement and standardize a nation's monitoring effort on a regional level. This system shows that the effort to establish clear regional criteria works as an effective incentive to operators, nations and observers for monitoring. As part of the program outputs to the public are naturally required such as the regional online database. The environmental management of the high-seas area has not been of significant interest by the Convention Parties until recently (Katsanevakis et al., 2015).

Compliance reports with each party's reporting status are published online in the UNEP MAP meeting document website. Penalties against any non-compliance issues are not articulated in the Convention. However, the parties can make recommendations to any such non-compliant party. Alternatively, a settlement of disputes provision exists and allows for an arbitration procedure to be undertaken (Art. 22; Annex A).

Table 4.1. Characteristics of the monitoring system for the Barcelona Convention.

Barcelona Convention Offshore oil and gas development monitoring			
	Convention - Compliance of measures	Offshore protocol	Integrated Monitoring and Assessment Program (IMAP)
What's monitored	• Compliance and effectiveness of measures to implement of 7 protocols	• Offshore environmental impacts Compliance and effectiveness of the offshore protocol • Common indicators and standards • Regional monitoring goals i.e. Offshore Action Plan*3	• Ecosystem common indicators (mostly chemicals) in common regional areas toward making a regional report • Cooperative monitoring goals • Regional areas (EBSAs*1)
Reporting	Three-triggered-reporting system	Nations' self-reporting based on operators' self-monitoring (National inspections and standards are required)	• Nations' self-reporting • Chronicle common reports
Review	• Review by the Contracting Parties and review and advice by Compliance Committee • Observers to examine non-compliance issues • Public disclosure upon inquiring	• Review by the Parties Guided by Offshore Oil and Gas Group and Sub Groups	Updating national programs
Enforcement/Penalties	Legally binding	• Legally binding • Compliance factsheets and questionnaires to nations and operators • National inspections	IMAP Action plans
Access to data		• Regional online database system • Periodical publication	
Confidentiality	Confidentiality	Confidentiality*4	
Others			High-seas area has been difficult to manage*2

*1 (Portman et al., 2013); *2 (Katsanevakis et al., 2015); *3 (UNEPMAP, 2017a); *4 Article 15.3 (UNEPMAP, 1995)

4.2. The Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention)

The development of the OSPAR Convention started with the Oslo Convention for the prevention of marine pollution by dumping from ships and aircraft in 1972 and the Paris Convention for the prevention of marine pollution from land-based sources signed in 1974. Being initiated by the 1992 Rio de Janeiro UN Conference on the Environment and Development, the OSPAR Convention was adopted in 1992. The Convention area is composed of five regions (the Arctic waters, greater North Sea, Celtic Seas, Bay of Biscay and Iberian Coast, and wider Atlantic), which include a large area of the High-Seas. The fifteen parties to the OSPAR Convention are Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and UK. The Convention promotes the implementation of "the ecosystem approach" for marine environmental management. The ecosystem approach is defined as;

> "*the comprehensive integrated management of human activities based on the best available scientific knowledge about the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of marine ecosystems...*" (OSPAR, n.d.).

Environmental monitoring of impacts caused by offshore industry has been engaged through the following four frameworks: the monitoring of the effectiveness of Contracting Parties' measures under the Convention and Annex, the Offshore Oil and Gas Industry focused monitoring regulated by the Offshore guidelines, and two overarching monitoring systems named the Joint Assessment and Monitoring Programme (JAMP) and the Coordinated Environmental Monitoring Programme (CEMP) (Table 4.2).

The OSPAR Convention (Article 5) stipulates the Contracting Parties' obligation to eliminate pollution from offshore sources. It is supplemented by the Annex III "On the Prevention and Elimination of Pollution from Offshore Sources". Parties are required to report periodically to the OSPAR Commission on the measures taken, effectiveness of the measures, and problems to implement the measures (Table 4.2). Those reports are reviewed by the Commission to assess the nation's compliance (Convention Art.22, 23). Thus, this compliance monitoring is important for the offshore monitoring too. Annex III constitutes a regulatory framework of the offshore environmental management, which includes a compliance monitoring obligation of the competent authorities of Parties by regulating offshore sourced substances and providing for the monitoring system (Annex III Art.4). The Convention does not contain any provisions of outputs of the compliance based on conditions or even of national reports, but it prescribes an obligation of Parties to provide access to information. Parties shall ensure their competent authorities make available the information on activities and measures upon a request within two months (Convention Art. 9). However, some exemptions are allowed by this provision -- one of which is for commercial confidentiality.

The Guidelines for Monitoring the Environmental Impact of Offshore Oil and Gas Activities (Table 4.2) have been developed by the OSPAR Commission since 2004 and revised in 2017 for more consistency in monitoring, reporting and data assessment (OSPAR, 2017). The guidelines define recommended monitoring standards to be referenced, recommended sampling targets and strategies for sediment and water column, and the obligation of contractors for quality assurance of monitoring data. Monitoring standards are required to refer to the Joint Assessment and Monitoring Programme (JAMP) and the International Organization for Standardization (ISO), and offshore monitoring is managed under JAMP (OSPAR, 2010, 2017). The monitoring strategy is characterized by two spatial scale approaches (field specific monitoring and regional monitoring) and the OSPAR list of monitoring parameters for water column and sediment monitoring, respectively. Field specific monitoring focuses mainly on baseline surveys to get temporal and spatial trends of contaminants, and regional monitoring aims to address larger-scale environmental patterns and effects from offshore activities. Sampling timing, station patterns and recommended sampling methods are addressed with the monitoring strategy. OSPAR lists are composed of chemicals assumed to come from drilling installations such as metals (e.g., Cd, Cr, Pb, Cu, Hg and Zn, total hydrocarbon content, PAHs), chemicals in fish, sediment grain size, and benthic fauna. The reporting and review system is based on the Contracting Parties' self-reporting (annual) and review by the Contracting Parties meeting and the Offshore Industry Committee. Information on discharged water, spills and emission is required to be open on the online OSPAR database system (OSPAR Data and Information Management System).

Partly coordinated by the EU Marine Strategy Framework Directive, the Joint Assessment and Monitoring Programme (JAMP) aims to describe the strategies, themes and products of the science-based monitoring and assessment and collaboration among the Contracting Parities from the perspective of the long-term benefits obtained from a high quality database and cost-reductions by collaborative monitoring (OSPAR, 2014) (Table 4.2). The current JAMP is for the years of 2014-2020 following after the first JAMP in 2010-2014. JAMP requests the Offshore Industry Committee to implement environmental assessments, monitoring, and data management and to report the outcomes (three products) in order to identify issues and materials and to document progress. The Committee is still on the way to clarify assessment methods for impacts caused by offshore substances such as discharged water. The Contracting Parties have to make annual reports with regard to the assessment and monitoring results, and the Offshore Industry Committee reviews the reports in terms of specific targets to report to the OSPAR Secretariat. The final goal of the data management product in the Offshore JAMP is to create a high-quality online database from the monitoring data.

The next role of JAMP is the Coordinated Environmental Monitoring Programme (CEMP), which aims to seek for the Contracting Parties' coordination of monitoring to facilitate common and coherent data analysis and assessments in environmental monitoring to address specific questions raised by JAMP (OSPAR, 2016) (Table 4.2). Offshore industry is one of the thematic topics. In addition to JAMP, the Contracting Parties implement the CEMP monitoring and report annually, which is reviewed by the Offshore Industry Committee. The OSPAR data management system is regarded as a collaborative hub. Data compatibility and transferability is required.

To summarize, the offshore industry monitoring system under the OSPAR Convention is characterized by multiple monitoring targets and committees to identify issues and methods, following a set timeline as suggested by the OSPAR strategies. The system has introduced standards from the beginning and made each nation implement these standards, rather than expanding nation's monitoring effort and standards to a regional level shown in the Barcelona Convention. It is shown that the effort to recommend clear standards and goals works effectively to the Contracting Parties. The system also recognizes that a common database and collaborative monitoring efforts would be beneficial in terms of value and costs for all Parties. Some uncertainty still remains with respect to the relationship between a national monitoring and the OSPAR, however, clear targets and standards and outcome reports might reduce the uncertainty.

With respect to penalties to non-compliance issues, the Contracting Parties discuss recommendations to the non-compliant party. Or, the Contracting Parties may utilize the settlement of disputes provisions. From the document archive in the OSPAR website, the Offshore Industry Committee periodically overviews the compliance status of measures of each party, and publishes a report (e.g., OSPAR, 2009).

Table 4.2. Characteristics of the monitoring system for the OSPAR Convention.

OSPAR Convention Offshore oil and gas industry monitoring				
	Convention -Compliance	Offshore oil and gas industry monitoring*1,2	Joint Assessment and Monitoring Programme (JAMP)	Coordinate Environmental Monitoring Programme (CEMP)
What's monitored	• Effectiveness of measures • Problems • Compliance	• Environmental impacts and hazardous • OSPAR list of specific chemicals • Field specific monitoring Regional monitoring	• Assessment to identify issues and materials caused by offshore activities • Quality assurance policy (standard monitoring items; technical guidelines)	• Common and coherent environmental assessment targets for offshore activities • Coordinate components to be monitored
Reporting	National self-reporting	National self-reporting (annual monitoring report) (toward joint reporting)	Assess and monitor impacts written in national reports (annual)	National self-reporting (annual)
Review	The Commission assesses nation's compliance	Offshore Industry Committee	JAMP related to the offshore theme reviewed annually by Offshore Industry Committee	CEMP related implementation reviewed annually by Offshore Industry Committee
Enforcement/Penalties		Quality Assurance obligation Sampling strategy	Assessment sheets	
Access to data	• Information disclosure upon request • Nation's obligation to supervise domestic authorities for access to information	• OSPAR database on discharges, spills and emissions • OSPAR Data and Information Management System	• OSPAR database on discharges, spills and emissions • OSPAR Data and Information Management System • High quality database for long-term value	OSPAR Database
Confidentiality	Confidentiality	Confidentiality		
Others	Legally binding	• 1999 and 2010 OSPAR Strategy • 2017 Offshore Guidelines • Led by overarching monitoring program JAMP and CEMP	• OSPAR Strategy EU Marine Strategy Framework Directive • Common goals with clear process • Long-term cooperation to reduce costs • Common indicators	Collective management with other entities

4.3. FAO and regional fisheries management organizations in the deep-sea fisheries management

The deep-sea fisheries management on the High Seas is challenging because of the deep-sea species and ecosystem vulnerability and the difficulty in developing governance of resource management . To ensure the long-term conservation and sustainable use of marine living resources, FAO adopted the International Guidelines for the Management of Deep-sea Fisheries in the High Seas in 2008 (FAO, 2009). The guidelines themselves established a management framework and roles for nations, FAO and regional fisheries management organizations (RFMOs), although they are not legally binding. Some consider that Vulnerable Marine Ecosystems (VME) can be significantly affected by deep-sea fisheries. Thus, assessment and monitoring the effects of deep sea fishing on VME is a key item in the FAO guidelines and other RFMO efforts. This section explores the VME monitoring by FAO and by a RFMO, CCAMLR.

4.3.1. FAO Deep-sea Fisheries Management Guidelines

The FAO defines the vulnerability as;

> *"related to the likelihood that a population, community, or habitat will experience substantial alteration from short-term or chronic disturbance... The most vulnerable ecosystems are those that are both easily disturbed and very slow to recover, or may never recover... The vulnerability of populations, communities and habitats must be assessed relative to specific threats" (FAO 2009).*

Also, FAO defines criteria to identify the VME in the guidelines. These are uniqueness or rarity of habitats and discrete feeding areas, functional significance of the habitat, fragility by anthropogenic activities, recovery difficulties such as slow growth rates and long-lived species, and structural complexity such as complex physical structures and high biological diversity (Guideline 42).

RFMOs and States have the following obligations for VME, i.e., to adopt and implement measures for the prevention of significant adverse impacts on VMEs (Guidelines 21); to conduct baseline survey to identify of the areas where VMEs are known or likely to occur (Guideline 21); to conduct impact assessments for impacts which are caused by fishing on the VME (Guideline 47); and to develop data collection procedures and programs (Guidelines 31, 32). Here, States could be acting as flag States, port States, importing and exporting States, and jurisdictional States, and they are required to establish and implement national policy (Guideline 24, 26) for VME monitoring.

In the reporting and review system, States need to submit a report and data to a RFMO where one exists and to FAO directly if there is no RFMO, and are States required to ensure regular reviews on the report. States and RFMOs also need to make the reporting and analysis as transparent as possible to facilitate the review of the effectiveness of measures (Guideline 39, 81).

For enforcement and compliance, RFMOs and States have to implement monitoring control and surveillance systems (MCS systems) and ensure the compliance through the use of systems such as on-board observers and electronic and satellite-based vessel monitoring systems. RFMOs and States are required to close such areas to deep-sea fishing until appropriate conservation measures are established to prevent significant impacts on VMEs (Guideline 66). Currently, FAO has established the FAO Fishing Vessels Finder and the VME Database based on agreement with the United Nations General Assembly Resolution 61/105, both of which use the data from RFMOs and States (FAO, n.d.-a, n.d.-b).

To conclude, FAO's role is to make international rules to enforce FAO Code of Conduct ,FAO Port State Measures, and RFMOs' measures in international jurisdictions or ports of States, and to guide RFMOs to manage appropriate conservation measures to protect

VMEs. FAO attempts to establish a concrete system including the contents of conservation measures to each RFMO's efforts. The FAO approach is particularly relevant to marine flora and fauna as well as biodiversity monitoring in deep sea ecosystems.

Table 4.3. Characteristics of the monitoring system for the FAO.

FAO Vulnerable Marine Ecosystem (VME) monitoring		
	FAO Guidelines	VME
What's monitored	Compliance and effectiveness of VME conservation measures	• VME data • Impacts on the VME by Deep Sea Fishing (DSF) and in DSF areas • Vessel locations • Gears • Stocks
Reporting	• National Self-reporting Monitor by local RFMOs	• National Self-reporting • Monitor by local RFMOs
Review	Review by RFMOs (or FAO if there's no jurisdictional RFMO)	Review by RFMOs (or FAO if there's no jurisdictional RFMO)
Enforcement/Penalties	• Inspection by observers and port states • Not legally binding	Inspection by observers and port states
Access to data	Not enough access to the High-Seas	• FAO VME Database • FAO database of ships (Fishing Vessel Finder)
Confidentiality		
Others	International cooperation with states, RFMOs and voluntarily groups	International cooperation with states, RFMOs and voluntarily groups

4.3.2. The Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR)

The Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR Convention) entered into force in 1982 to conserve the Antarctic marine life such as finfish, molluscs, crustaceans and all other species of living organisms including birds under the Antarctic Treaty System. The establishment of the Commission of the CCAMLR was in response to increasing commercial interest in Antarctic krill resources in the late-1960s and mid-1970s, and initiated by the Antarctic Treaty Parties' recommendations. Before the CCAMLR, the Antarctic Treaty system had established the 1972 Convention for the Conservation of Antarctic Seals and the 1964 Agreed Measures for the Conservation of Antarctic Fauna and Flora. These conventions were later also arranged into the Protocol on Environmental Protection to the Antarctic Treaty in the Annex II (Conservation of Antarctic Fauna and Flora) in 1991.

CCAMLR is now composed of 25 Members and 11 acceding countries, and the member nations have obligation to work for “the Commission (so-called CCAMLR)", a decision-making body, and “the Scientific Committee”, an advisory body to make recommendations to the Commission. CCAMLR has practiced an ecosystem-based management approach, which does not exclude harvesting marine resources. Its important policy instruments are legally-binding or non-binding conservation measures that determine the use of marine living resources in the Antarctic based on the best available scientific information. The CCAMLR Commission meets annually in October in Hobart, Tasmania, AU. It has two subsidiary bodies; a Standing Committee on Implementation and Compliance, and a Standing Committee on Administration and Finance. The Scientific Committee has four working groups and one specialist subgroup.

The Convention area is defined by the Convention Article I, and it consists of all waters between the Antarctic Continent and 60°S latitude and of the area between 60°S latitude and the Antarctic Convergence. The Convention area covers around 10 percent of the Earth's surface and has a surface area of 35,716,100 km2. It is noted that the CCAMLR area is somewhat different than the Antarctic Treaty area (south of 60° S Latitude) and from the MARPOL Antarctic Special area (sea area south of latitude 60° S).

CCAMLR has established conservation measures to protect VMEs through the Scientific Committee and Working Group on Ecosystem Monitoring and Management. A primary purpose of these conservation measures is to manage and restrict some deep-sea bottom fishing and gears that would bring adverse impacts on the VMEs. Conservation measure 22-06 (the bottom fishing in the Convention Area) (CCAMLR 2017) constitutes the main regulatory framework to who wish to engage in any bottom fishing activities in the Convention Area. First, proposed fishing activities are required to be pre-assessed by the Scientific Committee with respect to whether or not they would make significant adverse impacts on the VMEs (CM 7). The Contracting Parties have to submit reports on the proposed activities, known and anticipated impacts, and mitigation measures based on the best available data. With the Science Committee's recommendations, then, the Commission will adopt conservation measures to prevent the impacts on the VMEs on the conditions such as whether they allow or prohibit the activities and certain types of gears.

To monitor those bottom fishing activities, all Contracting Parties are required to comply with the authorized gear, carry at least one CCAMLR-designated science observer, and submit related data for the Data Collection Plans for bottom fisheries to be developed by the Scientific Committee. The CCAMLR Secretariat is required to provide open access to these vessel data on the website. Based on the fishing vessel information, the Science

Committee shall advise the Commission to create VME maps, and these VME lists and risk areas are shared by the Secretariat as the CCAMLR VME Taxa Classification Guide 2009 and Online GIS map (CCAMLR, 2009, n.d.-a). This data provision is regarded as the one of the Contracting Parties' most important obligations. The conservation measure is reviewed by the Commission at the regular meeting, especially in terms of the effectiveness of relevant conservation measures to protect VMEs.

To monitor new VMEs, CCAMLR also requests the Parties to report to the Secretariat when they encounter VMEs or affect them incidentally such as in by-catch in the Convention area under conservation measures (CM22-06, CM22-07). The report should include the location, sampling gears used, supporting evidence and detailed evidence of VME taxa observed. This report is reviewed by the Working Group of the Ecosystem Monitoring and Management under the Science Committee.

For the review and evaluation of compliance of those conservation measures, CCAMLR has adopted a conservation evaluation procedure (Conservation measure 10-10, 2017). First, the Secretariat prepares a draft compliance report from the Contracting Parties' information on the issues in implementation of measures, which is circulated to and revised by the Parties with additional data and produced as a summary compliance report. Second, at the annual meeting, the Standing Committee of Implementation and Compliance (SCIC) reviews and evaluates the summary report and makes recommendations on any remedial actions that should be taken by the Parties and other responsive actions considered by the Commission. Finally, at the annual meeting, the Commission considers and makes decisions on the response taken to the Parties. The final compliance report is available online as part of the CCAMLR annual meeting report (CCAMLR, 2017).

CCAMLR has prepared standards for ecosystem monitoring through the CCAMLR Ecosystem Monitoring Program (CEMP) since 1989 (CCAMLR, 2014). The major function is to monitor the key life-history parameters of selected dependent species to detect changes in the abundance of harvested species. However, the indicator species used in CEMP are some kinds of seals, petrels and penguins, and not fishery VMEs.

To summarize, the CCAMLR's VME monitoring system is regulated by compliance with its conservation measures. The conservation measures are divided into multiple fields such as the necessary assessment procedures before fishing, permitted and prohibited gears, detailed instructions on how to establish VME areas. Moreover the conservation measures themselved are reviewed frequently by the Commission so they may be able to reflect the latest data and knowledge to be usedto implement the best available data and science. After a nation's self reporting, the compliance review system is managed by the Secretariat, and the compliance specialized committee, the Commission, and this information is found in a publicly available final report, which is transparent. The proces and procedures to create a preliminary compliance report based on consulting nation reports requires a certain high capacity for the Secretariat. An obligation to report previously unknown and new VME by contracting parties may be effective as a monitoring method when it comes to deep seas where few data exist. These CCAMLR system elements are particularly important for living marine resources in the ISA Area.

Table 4.4. Characteristics of the monitoring system for the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR).

CCAMLR - Vulnerable Marine Ecosystem (VME) monitoring			
	Conservation measures	Unknown VME	CCAMLR Environmental Monitoring Program
What's monitored	• Compliance and effectiveness of measures • Vessel • Gear (Long lines, bottom trawls, mid-water trawls, gillnets and traps/pots) • Stock	• Areas / Habitat	• Specific species change in long term
Reporting	National Self-reporting	• National self-reporting	• National cooperation
Review	• Annual review of measures • Multiple Review by the Secretariat, Compliance Committee, Commission	• VME list revision	• Assessment by Science Committee
Enforcement/Penalties	Inspection by onboard observers		
Access to data	• Compliance reports • CCAMLR database • FAO Vessel Monitoring System (satellite and ships' radio signal)	• CCAMLR online database	
Confidentiality			
Others	• Cooperation with states, RFMOs and voluntary groups • Limited enforcement access to the High-Seas		• International cooperation with states, RFMOs and voluntary groups

4.4. Monitoring of EEZ Offshore Oil and Gas Drilling by the US

The US offshore drilling management monitoring program was changed after the Deep Water Horizon Oil Spill occurred in 2010 Conflicts in management occurred in part as the result of a single organization's management of both leasing and inspections within the Minerals Management Service of the US Department of the Interior (Baur, Eichenberg, Snusz, and Sutton, 2015). In 2011, two new agencies were created under the Department of Interior: the Bureau of Ocean Energy Management (BOEM) issues leases and manages the offshore resources in an environmentally and economically responsible way; the Bureau of Safety and Environmental Enforcement (BSEE) provides an inspection force to promote safety culture in offshore operations.

The environmental management of the US offshore mineral mining is framed by a stringent permit process taking into account any related US regulations and standards, regular and unannounced inspections, and thematic monitoring programs. The Outer Continental Lands Act of 1978 constitutes the regulatory framework for leasing. The process employs a national five-year Program to schedule the potential lease size, timing, and location, based on which the BOEM calls for lease sales. BOEM is required to coordinate meetings with stakeholders from federal agencies to interest groups to input comments and conditions for the new lease sales and to draft an Environmental Impact Statement (EIS). The draft EIS includes proposed actions, alternatives and mitigation measures, has to be reviewed publicly as well as reviewed under the US Coastal Zone Management Act and other required regulations. After the final notice of lease sale, BOEM makes any information of bids opened to public (Baur et al., 2015).

The next process for the approval to start lessees' activities is the submission of Exploration and Development Plans by lessees to BOEM. Lessees also must submit environmental information, biological monitoring reports, and bottom survey reports. The proposed activities have to comply with any related requirements and regulations such as the National Environmental Policy Act, the Endangered Species Act, and the Marine Mammal Protection Act. BOEM reviews these plans with respect to various criteria such as water and air quality, oil-spill response and compliance with other laws and regulations. This process is in cooperation with other regulatory mechanisms and agencies such as the Environmental Protection Agency and the National Marine Fisheries Service, and also in cooperation with affected states for a consistency review (Baur et al., 2015).

BSEE conducts project-specific safety reviews to ensure that the operator uses the technologies and equipment which meet design criteria and performance-based standards. This comes from the Best Available and Safest Technology principle of the Outer Continental Shelf Lands Act (BSEE, n.d.-a). BSEE is required an annual inspection of the operators' safety equipment (to prevent blowouts, fires, spills, etc) with random follow-up inspections. For enforcement, BSEE may charge a violating operator a civil penalty (up to $100,000/day) or a criminal penalty and suspension of the operation (Baur et al., 2015). The inspection includes the purpose of environmental oversight to ensure the operators' compliance with environmental standards, which is managed by the Environmental Compliance Division of BSEE (BSEE, n.d.-b).

To prevent oil spills in operations, BSEE reviews and approves of oil-spill response plans from operators, and inspects oil-spill contaminant and cleanup equipment. For the discharged water from drilling rigs in the Gulf of Mexico, Alaska and West Pacific regions, the Environmental Protection Agency issues water permits and has responsibilities in its monitoring, which is carried out by BSEE (BSEE, n.d.-c).

The websites of the Data Center of BOEM and BSEE shares access to various kinds of information on leases, operators, wells, production data, plans, etc. Detailed inspection reports such as on an operator's non-compliance status are not found, but BSEE publishes an annual report on the inspection results and the number of non-compliance incidents in order to evaluate performance (BSEE, 2016a). Non-planned discharges or releases of polluted water need to be reported by operators or by anyone who notices the discharge to the National Response Center in the Coast Guard. This information are publicly available online (USCG, n.d.).

BOEM has started long-term environmental monitoring of the big oil-spill region in the Gulf of Mexico for restoration and recovery to complement other short-long term science-based environmental study programs (BOEM, 2017, n.d.).

Recently regulations have been amended to require operators to use remote real-time monitoring using satellites in their offshore operations (BSEE, 2016b).

To summarize, the US offshore monitoring is managed by the stringent lease permit process in accordance with multiple regulations, which is managed by BOEM, and by multiple inspections by BSEE. It appears that effectiveness of monitoring, and reporting relies the two agencies being separate. This system seems not to depend on operator's self-reporting efforts, but more on the strict standards and enforcement mechanisms by the government. The environmental damage caused by oil spills such as the Deepwater Horizon Oil Spill is huge, however, it is argued that the current firm’s liability compensation cap is too small and the liability mechanisms do serve adequately as an incentive for those firms to tighten self-regulation (Hasson et al., 2013; Scovazzi, 2012). This system also looks that they have not implemented many environmental monitoring frameworks after the Deepwater Horizon Oil Spill.

Table 4.5. Characteristics of the monitoring system for the US offshore oil and gas drilling.

The US offshore oil and gas drilling			
	Leasing by BOEM	Rig monitoring by BSEE	Thematic and regional monitoring by BSEE, BOEM, Other agencies
What's monitored	• Lease	• Compliance of permits • Standards (Best Available Safe Technologies) • Discharged water quality (by EPA)	• Oil spills • Environmental recovery from big spills • Science studies
Reporting	• Operator self-reporting (Plans)	• Multiple inspections	• Other-reporting (Reports from agencies and scientists)
Review	• Review by multiple agencies, states and public		
Enforcement/Penalties		• Irregular inspections • Civil and criminal penalties	
Access to data	• Public access to data through websites • Various stakeholders participation	• Information disclosure depending on agency decisions	• Public access to data through websites • Online oil Spill information site (USCG)
Confidentiality	• Business secrets are confidential	• Compliance detailed reports are not open	
Others	• Various standards	• Strict Standards (Technologies, environment quality)	• Science research

4.5. Monitoring of the EEZ seabed mineral mining by Papua New Guinea

The government of Papua New Guinea (PNG) has carried out mining of the mineral deposits of seafloor massive sulfides in its EEZ on the seabed shallower than 1600 m) since the 1990s under the Solwara 1 Project. The operator is Nautilus Minerals Inc. (hereafter, Nautilus), a Canadian mining company. It seems that Nautilus' interest is not only in the profit from mining but also in the establishment of the company's reputation as the first successful company in the commercialization of seabed mineral resource exploration and exploitation in the world.

The UNCLOS requests coastal States to adopt laws and regulations to prevent, reduce and control pollution of marine environment in their EEZs and such regulations have to be no less effective than international rules, standards and recommended practices and procedures (UNCLOS Article 208). Thus, in order to start seabed mining, PNG established the Mining Act 1992 (amended) and the Environmental Act 2000 (amended in 2014) (PNG, 2000, 2014). The Mining Act 1992 vests ownership of all minerals including seabed with the national government, and governs the exploration, development, processing and transport of minerals. The Environmental Act 2000 sets all necessary regulatory systems for the management of environmentally impacting activities such as the Solwara 1 Project. PNG issued a mining license for resource exploration to Nautilus in 1997 (Nautilus, 2012). Nautilus commenced the EIA research project in 2007 and submitted an Environmental Impact Statement (EIS) to the PNG government in 2008. In 2009, the government issued a permit for commercial mining for 25 years. Nautilus has been developing seabed mineral collecting machines (Nautilus Minerals, 2018b), pending an announcement that the commercial mining would start soon (Radio Australia, 2015), although they have not commenced as of the time of this thesis June 2018.

The Environment Act 2000 is administered by the PNG Department of Environment and Conservation, renamed the Conservation and Environment Protection Authority (CEPA) in 2015, under which the most powerful and functional position is given to the Director of Environment. The Director has power to issue any permits related to the Act, to ensure that EIAs are carried out, to undertake environmental inspections, to enforce provision of the Act, to take appropriate measures to protect the environment, and to prepare and submit reports on issued permits and other matters to the Minister (PNG, 2000). There is an advisory body to the Director, the so-called "the Environment Council" , and it makes recommendations to the Director and the Minister, reviews decisions of the Director, and makes environmental policies. However, the Director serves the Council's Chairman, but the reviews are upon request of the Director (Art. 68). Therefore, it seems that the actual review and enforcement of functions of this system mostly rely upon the Director once the policies and regulations are established.

In PNG environmental permits are classified on three levels, and Solwara 1 was defined as a level three activity, which involves matters of national importance or results in serious environmental harm (Art. 42). To apply for an environmental permit for level three activities, the Director and the operator are required to conduct an EIA process (Art. 50). In the EIA process, the operator submits an inception report and an EIS, and then, the Director assesses the EIS and conducts public review of the EIS. If the Director accepts the EIS, the Council determines a referral of the EIS based on the Director's assessment report and public opinion submissions, and the Minister issues a final approval (Arts. 51, 53, 54, 55). The inception report has to list the issues to be assessed in the EIS, which must be covered by the EIS. The main points of a referral by the Director and the Council are whether (1) the EIS contains an adequate description of the nature and extent of physical and social environmental impacts, and (2) all reasonable steps will be taken to minimize environmental harm (Art. 58). The environmental permit when approve may be conditioned with requirements for the operator such as conducting baseline studies and carrying out a specified monitoring program at the cost of the permit holder (Art. 66). According to Nautilus' technical reports, Nautilus has already finished and submitted the environmental management plan in 2017 (Nautilus Minerals, 2018a), although this report is not made publicly available.

For the enforcement and punishment, the Director or a person appointed by the Director can audit and investigate the operator's activities, compliance reports and management plans submitted by the operators for the cause of environmental harm (Art. 74). If the operator fails to comply with or gives false or misleading information, then the operator is regarded as guilty of an offence with the penalty of a fine not exceeding K100,000 (~USD31,000 as of April 2018) (Arts. 74, 114).

With respect to information collection, the Director can collect and store data related to the environment and asks the operators to provide such information, however, any confidential information is excluded (Art. 77). There is no information sharing policy in the Environmental Act.

Nautilus' environmental impact survey in 2007-2008 was based on a large amount of the baseline data and workshop results conducted by collaborating scientists and contracted assessment companies. Nautilus summarized the environmental background in the Solwara 1 field, presented the impacts of mining to each environmental category, and suggested mitigation methods for each environmental category in the EIS report. Nautilus' assessment process consisted of a baseline survey, international workshops with scientists and stakeholders, estimation of possible risks from industrial steps, estimation of potential impact assessment (31 environmental effects), estimation of possible mitigation strategy (for 31 environmental effects), and creation of mitigation strategies. Each part of the assessment process incorporated international standards, domestic PNG requirements as well as an estimation of residual impacts (after mitigation).

In the EIS, Nautilus also proposed a preliminary environmental monitoring plan including anticipated impacts, proposed baseline studies, and proposed monitoring and mitigation methods for each environmental issue such as "Concentration of contaminants in the return water discharge" and "Light, noise and vibration that seafloor mining tool creates will attract animals" (Coffey Natural Systems, 2008). As described in the published EIS, the monitoring program would include the compilation of baseline surveys, an intense short-term validation study of discharged water, and operations monitoring to ensure regulatory compliance and to identify unforeseen effects. Nautilus was willing to provide PNG the compliance reports and to conduct internal assessment of implementation of environmental management programs.

For the EIS, Nautilus had a strong relationship with worldwide scientists who were interested in minerals deposits, and used a number of high-level observation data as supporting materials for the EIS. This is a wise strategy to collect data promptly in an unknown field by using scientists' interests and capacity. The full citation of the supporting reports and contributors in the EIS and its open policy are highly evaluated in terms of transparency. However, they did not conduct a pilot mining test for the EIS, and used only model simulation and scientific level tests, which is different from the earlier US environmental impact assessment projects for deep sea mining (Chapter 1) as they estimated impacts from test mining experiments at sea.. The expected mining activities are four types (the operation of the seafloor mining tool, mining support vessels, ore barging, and other activities within the PNG port). Nautilus once mentioned that the area of Solwara 1 is quite small (0.112 km2) and its EIA is too much study for just this project.

To summarize, the environmental management in PNG's seabed mineral mining project is controlled by law enforcement under a single government environmental agency (CEPA). The management and decision making power is centralized in the Director of the Authority, even though the system has a decision making body, the Council. To get a final environmental permit for commercial mining, operators such as Nautilus are required to perform self-reporting of an intercept report and EIS and obtain an approval from the Director and the Council. This system does not have a critical internal review system supplied with sufficient environmental expertise to be able to supply further suggestions for improvements Regarding environmental monitoring, it also seems that the system relies on the operator's monitoring plan. Due to very limited information availability on the PNG government websites, it is difficult to analyze what and how PNG has made decisions on the environmental management and monitoring to be performed by Nautilus. The information from the Nautilus side that the public can access is the EIS and some technical reports. In this sense, PNG's environmental monitoring system's transparency is rated to be low.

Table 4.6. Characteristics of the monitoring system for the Papua New Guinean seabed mineral mining.

Papua New Guinean seabed mineral mining		
	Leasing - EIS	Environmental management plan
What's monitored	• Lease • Baseline data • Anticipated impacts • Mitigation methods • Ambiguous requirements	Environmental harm (by negotiation with the agency)
Reporting	Operator self-reporting (Plans, EIS)	Operator's self-reporting (by negotiation with the agency)
Review	• Review by the Director of the Department of the Environment • Public comment on the EIS	Negotiation between the agency
Enforcement/Penalties	• Monetary fine for false/misleading information provision Seizure order by government [not mentioned in text]	
Access to data	EIS has been published by a contractor	• Not publicly reported • Almost no information disclosure to PNG other than operator self efforts • No data sharing mechanism with anyone
Confidentiality	Confidentiality	
Others	Not enough standards Less functional Authorities	Adequate framework not established or publicly open

Table 4.7. Summary of the characteristics of monitoring systems in the case studies.

	What's monitored	Reporting	Review	Enforcement	Penalties	Access to data	Confidentiality
Barcelona Convention	Effectiveness of measures to prevent pollution and changes to regional common indicators	Three tired reporting system	Multiple review by authority functions, Observers	Recommendations	Discussed by the Contracting Parties	Online database, Meeting documents (Compliance reports)	Business information
OSPAR	Effectiveness of measures to prevent pollution and changes to OSPAR indicators	Self-reporting, Common reporting among States	Review by the authority, Observers	Recommendations	Discussed by the Contracting Parties	Online database, Meeting documents (Compliance reports)	Business information
FAO	Adverse effect causes on VMEs such as vessels, gears and fish stocks submitted by RFMOs			Inspection, Activity ban in the area	No penalties	FAO database	
CCAMLR	VME conservation measures and unknown VME habitats	Self-reporting	Multiple review by authority functions	Inspection, Activity ban in the area	Compliance report to public	CCAMLR online database, FAO database, Others upon request	Business information
US	Standards usage status and oil spills	Self-reporting	Review by the authority and public	Multiple inspection, Government order of suspension and termination	Fine	Online database	Business information Detailed info on non compliance
PNG	Environmental harm caused by mining activities	Self-reporting	Review by the authority, Public review	Inspection, Government Order	Fine	No instruments	Any information could be confidential

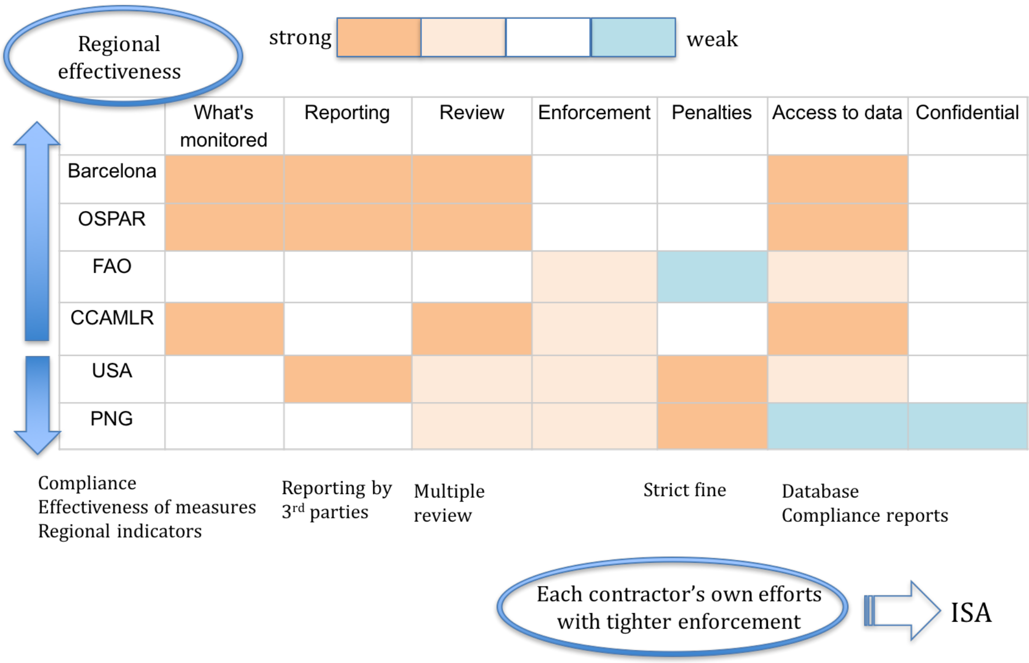

Figure 4.1: Summary of the results from the case studies. Color indicates the extent of richness and robustness of instruments implemented in terms of the system's transparency and effectiveness.

4.6. Conclusion of case studies

The case study shows that international regimes such as the Barcelona Convention, OSPAR and CCAMLR have been enhancing the rules and capacities to monitor compliance, the effectiveness of measures, and regional and thematic indicators in order to achieve the higher effectiveness of monitoring regionally (Table 4.7; Fig. 4.1). These points are not developed in national monitoring such as the US offshore and PNG practices. International monitoring also has focused on implementing more transparent reporting and review system e.g. using third party's reporting and multiple reviews of reports and data. The regional efforts are considered effective for the purposes to make clearer standards and facilitate collaboration among states to eliminate uncertainties. National monitoring tends to have established a certain amount of clear standards for the strict enforcement of non compliance before a lease is issued to a contractor as shown in the US case.

International regimes do not establish strong instruments in enforcement and penalties as compared with national monitoring which relies on law enforcement and strict penalties such as monetary fines. The difference of these monitoring characteristics may be partly caused by the difference in management area sizes to be monitored and enforced between international multilateral regimes and national regimes.

In terms of access to data, most cases except for PNG regard database as an important strategy for the effective management and developed higher quality database with clear objectives. On the other hand, they keep confidentiality of some information such as business secrets, and the confidentiality may be universally inevitable for every company and industry to maintain their business stability. It is important that the monitoring system should be designed enough effective and transparent without publishing confidential information.

Chapter 5. Recommendations

5.1. Institutional options to be considered to the ISA monitoring systems

This chapter examines the options for improving the ISA monitoring system for deep seabed mining (exploitation) in terms of monitoring characteristics taking into account the ISA monitoring analysis in Chapter 3, Case studies in Chapter 4, and stakeholder opinion analysis summarized in Appendix A.

In contrast to other international case studies, the ISA manages mining contractors' contracts and activities directly. In the Barcelona Convention and OSPAR regimes, the main actor is a member state: they implement international standards and measures to national contractors in cooperation with other states. However, in the ISA system, contractors are the main actors even though their sponsoring states supervise them financially and in respect to implementing measures. Therefore, the ISA system is more similar to the US offshore and PNG mining monitoring systems.

The US offshore system manages operators with multiple standards, regulations, tight inspections and penalties. In contrast, the ISA system has many uncertainties in its standards, its enforcement function is ambiguous and the compliance review system is not defined clearly. No penalty has been imposed by ISA for non-compliance by contractors so far (Chapter 3). However, it is not clear that all contractors are equally diligent in monitoring and reporting on prospecting and exploration activities. In the current ISA system, I assume it might be difficult for ISA to enforce a penalty on a contractor beyond the state's jurisdiction. In this sense, the ISA's inspection and enforcement system may not be able to adopt the US offshore monitoring type of oversight and inspection (Fig. 4.1).

At the same time, ISA could follow the framework of international environmental management regimes such as OSPAR (ISA, 2017; ISA referenced OSPAR in the Draft exploitation environmental regulations) and RFMOs with respect to supervision of contractors. The ISA system relies on the member states for supervising of their sponsored contractors. But it is not clear who is the most responsible for the problems associated with environmental impacts. Is that the role of states or the international institution?

Another issue lies in the focused power and responsibilities of the Secretary General. Review mechanisms for the effectiveness of measures and the evaluation of the environmental baselines and impacts are basically conducted between the Secretary General and contractors. No information disclosure policy is stipulated in the regulations. It is expected that this issue would lower the effectiveness of the environmental management in regional and larger spatial scales and would cause further transparency concerns.

Taking these aspects into an account, my thesis proposes that ISA should strengthen the review and enforcement institutions which are already codified, and that ISA should increase it capacity to monitor status of contractor compliance. At the same time, ISA should explore developing a monitoring and review system which could enhance the knowledge and effectiveness from a whole system perspective. Detailed options to improve the system are outlined in the following sections: what is monitored, reporting, review, enforcement, penalties, access to data, and confidentiality of information.

5.2 Characteristics of monitoring programs

5.2.1. What is monitored

A) Clear goals based on the priority

ISA should establish clear goals for the environmental monitoring. The current system does not have specific goals. If the goal is protection of biodiversity and mitigate the biodiversity loss from mining, they could establish a monitoring plan more focusing on biological survey using specific methodologies in the first stages.

B) Clear common standards and measures among contractors

ISA has not yet established standards and measures for deep seabed monitoring of exploitation except for some baseline survey methods. This raises many uncertainties for contractors (e.g. Germany, African group; Appendix A). It can be argued that indicators to measure environmental impacts and conditions, e.g., the indicators set by the Barcelona Convention and OSPAR should be established (see Chapter 4.1, 4.2). Those measures should be revised periodically based on the assessment of their effectiveness as is done by CCAMLR (see Chapter 4.4).

5.2.2. Reporting system

A) Collective monitoring and reporting of the environmental data

Collective monitoring among contractors is encouraged in the ISA regulations and CCZ environmental management guidelines for both exploitation and exploration. It is also recommended in a regional environmental management strategy, which the ISA plans to install in future environmental monitoring guidelines, in order to research baselines of the ISA's marine protected areas, the Areas of Particular Environmental Interests (APEIs) (Draft Exploitation Environmental Regulations; 2018 ISA Workshop). However, this thesis recommends such a collective monitoring should follow baseline surveys in contracted areas as well as the APEI. First, because it is time efficient. From scientific perspectives, deep-sea baselines in the CCZ contracted areas contain huge uncertainties as pointed many scientists, e.g., Van Dover et al. (2017), but the temporal and spatial scales of the data obtained by a single contractor are limited. It would be very difficult to confirm the natural variations during the limited duration of the current exploration contracts, i.e., only 15 years maximum. Collective actions in surveys and reporting among contractors and states can shorten the total amount of time to obtain data and accomplish to understand the environment much larger scale. Second, collective monitoring facilitates the effort to establish standard and common methods, equipment, and environmental indicators. Both the Barcelona Convention and OSPAR regimes have implemented collective monitoring strategies to define common indicators to measure the environmental impacts. Third, costs could be reduced. Some nations have developed and own high quality monitoring technologies. The current options for the nations who do not have such monitoring technologies by themselves or ability to hire monitoring companies are limited. However, with this new option, nations can use other some nation's resources. This will promote technological transfer and capacity building too. It is important that ISA should leave some freedom to contractors in terms of the number and extent of such collective monitoring. The contracted areas sponsored by some developing nation such as Kiribati and Tonga were the reserved areas of developed nations, and some collective monitoring relationships seem to exist already. Fourth, the environmental data are technically subject to be made publicly available by ISA. At least in terms of the environmental baseline surveys other than surveys of nodules quality and distribution, the entrance of other contractors would not be difficult.

The further options of the collective monitoring could allow scientists through science programs and the public through a real-time monitoring using video cameras in water. Both would improve transparency issues as well.

B) ISA managed reporting of the environmental data

In this option, ISA prepares and manages all necessary vessels, monitoring equipment and platforms, measurement instruments and monitoring technicians and monitor the environment in contracted areas instead of contractors. Contractors and states pay the monitoring fees to ISA. This option could become a solution for the efficiency of baseline surveys and protection of contractors' confidentiality. Currently, each contractor's survey ships actually use home ports in Hawaii or Mexico which are close to the mining area, shipping their instruments to the port from the original country (personal communications with a Japan's EIA operator). Equipment and instruments for such deep-sea surveys are specialized. Thus, each contractor's monitoring could be integrated into one project by ISA, which would be more efficient. The data obtained are standardized and formatted in the same way. A concern is the amount of fees to be paid for collective monitoring. This type of monitoring has not been seen in the case studies, however, may fit to the deep sea monitoring due to the peculiar environment. The feasibility as a policy should be at least examined. Most contractors feel uncomfortable with the possibility of their monitoring responsibility changes by occasional amendments in requirements (e.g. MRE Ltd; Appendix A), but this policy option can clear the case for their environmental obligations.

C) Other-reporting system for compliance and emergency issues

In the Barcelona Convention system, the reports submitted by the Secretariat and other entities against any state are taken into the compliance committee meeting as a compliance issue. The US offshore system has a reporting and information provision system by anyone who notices unplanned discharges and oil spills from offshore rigs. The current ISA's reporting system of Annual reports and Environmental performance reports is basically contractor's self-reporting. Though Environmental performance reports are supposed to be an independent review, contractors still can manage the submission and the period is every five years. Keeping in view of the large scale of contracted areas on the high-seas, this self-reporting is not efficient and could not correspond when an unexpected emergency pollution happens. Any sources, whoever comes across the incidents e.g. scientists, commercial vessels, or contractors of a close area, should be allowed to submit a report, and ISA should investigate the report by a certain process. This would be beneficial as a boundary monitoring tool of mining plumes beyond multiple contracted areas, as for such a boundary monitoring issue concerned by German government (ISA, 2018b).

5.2.3. Review system

A) Compliance review committees inside ISA

Aside from the Secretary General's review, there is no review systems codified in the current and draft regulations (see Table 3.1 and 3.2; reporting and review rows). Most regimes in the case studies have a compliance review committee such as in the Barcelona Convention, OSPAR, and CCAMLR systems (Table 4.1, 4.2, 4.4). ISA should have an independent compliance committee to review annual and environmental performance reports and discuss the effectiveness of national measures and consistency of those measures to the ISA regulations. The compliance evaluation function is completely lacking in the current regulations and draft regulations comparing with the other cases, also as is pointed out by such literature as Ardron et al. (2018).

B) Environmental review committees inside ISA

The review process and roles of the LTC and Council for Annual reports is unclear in the regulations. As for Environmental performance review of every five years, contractors prepare the review and the Secretary General comments. It is lacking in transparency compared to other regimes. ISA should establish an environmental review committee. Ideally, this review committee should be independent. Currently, the LTC is involved in most review process such as a contract applications, annual reports, environmental performance reviews, however, this might cause failure. An example of such failure is the monitoring of the US offshore monitoring institution before the Deepwater Horizon oil spill (Chapter 4.5).

C) Analysis and evaluation of contractors' data by ISA or a third party

The idea of this proposal is that contractors directly send raw environmental data measured in the baseline and environmental impact areas to the "ISA data analysis team". Then, the team analyzes and evaluates the baseline and environmental impacts over the whole mining area of CCZ. The team would be composed of ISA-hired research experts and operated by an additional monitoring fee to be paid by contractors or states. As an advantage of this option, data are processed by standardized methodologies and criteria by the team, which would lead to a comprehensive baseline. Analysis costs and personnel that each contractor is supposed to hire to prepare could be reduced in an integrated manner. Second, contractors' confidentiality can be retained even if the data contain any sensitive information. Third, transparency and quality control of data can be more effectively managed compared to as system based on each contractor's self-reporting. This system has not yet been adopted in any case studied. This may be raised as a concern if it is perceived to prevent states' from building their own data analysis capacity or constraining a firm's business freedom. However, contractors usually hire environmental assessment companies to analyze their data and create a report. This does not always happen within a nation (e.g. contractor of Tonga hired an Australian company to prepare for its exploration report; Tonga Offshore Mining Ltd-Golder Associates, 2012).

5.2.4. Monitoring enforcement

Inspections are important tools to monitor contractors and enforce them to comply regulations especially if they are performed randomly or without prior notification. Some mining industry stakeholders dismiss the importance of random inspections. ISA should develop its inspection requirements in the regulations. Human inspection may be costly and constitute a monetary burden to contractors and states, and therefore it is important to make them very effective.

A) Inspections based on technical standards

Concise and practical inspections should prioritize the target. One of the practical inspection targets should be whether the contractor is actually using the required technologies and equipment such as is seen in the US offshore case (the best available and industrial technologies) (Chapter 4.5). ISA should establish those technological lists and standards.

B) Autonomous transmission of compliance data from mining ships

To reduce costs and increase transparency, autonomous and electronic submission of compliance data should be promoted. Such data as discharge water qualities, equipment settings and ship locations could be transmitted autonomously using current technologies. ISA should examine and learn the potential of real-time monitoring using satellite systems installed in the US offshore EEZ and CCAMLR (Chapter 4.4, 4.5) as well as the cost-benefit difference analysis between the real-time autonomous reporting and human inspections.

C) Boundary enforcement

ISA should discuss who would be responsible of the impacts caused by plume intrusions from the adjacent contract areas suggested by German government in the Stakeholder opinions (Appendix A), and establish inspection instruments. This could cause a jurisdictional legal matter.

5.2.5. Enforcement and penalties

A) **Clear criteria and multiple divisions in enforcement and penalty assessments**

ISA should articulate clear criteria of enforcement and penalties to be assessed for non-compliance. Currently, in the exploitation regulations, the Secretary-General is supposed to determine and enforce the compliance notice to contractors (see Table 3.1, 3.2; Enforcement rows). Based on review of other cases the assessment process should involve multiple divisions such as a compliance committee rather than the Secretary-General.

B) A rating system of contractors

ISA should establish a rating system of contractors in regard to the extent of their contributions to compliance, scientific research, and access to information as a social mechanism to evaluate and promote compliance and awareness. The System for Transparent Allocation of Resources (STAR) implemented by the Global Environmental Facility (GEF) to evaluate the GEF-funded country's performance to improve the environmental issues based on transparency (Global Environmental Facility, 2013) and the Environmental Performance Index (EPI) which scores 180 countries on 24 performance indicators would be a good example (Yale University, 2018)

C) A grace period of amended regulations for good contractors

ISA should examine political rewards in addition to the current penalty system. Political rewards are often more effective than monetary penalties if the contractors are wealthy and not strongly supportive of the regime's norms (Mitchell, 1998). Contractors are afraid that ISA would change the contact terms and conditions every time regulations are amended once mining starts (see Appendix A).

5.2.6. Access to information

A) Transparent access to ISA workshops

ISA organized workshops are intended to perform the function to assist in drafting monitoring guidelines. At these workshops are very limited opportunities for the public, experts and observers to make comments. However, most of the workshops are closed subject to the ISA Secretariat's invitation. This attitude is against the ISA's policy as stated in the 2011 CCZ management guidelines and contrary to the spirit of the Common Heritage of Mankind (CHM). Using such technologies as a webinar conference system, ISA should be able to manage a large audience.

B) Compliance status and meeting documents

The current ISA regulations do not stipulate that there be public access to the information on compliance status. The case studies in Chapter 4 show that most international management regimes report such information on the compliance status of each state. Although complete access might raise controversy with respect to contractor performance, even if non-compliant company names are not publicly released, ISA should report non-compliant activities and the countermeasures being taken. Such a process should become a safeguard to finding a flaw in the review system within contractors or inside the ISA Secretariat In addition, more meeting documents such as that of the LTC meeting and regional session meetings should be made publicly available. Currently, the chairman's report on LTC is publicly available but it presents an extremely small amount of information.

C) Parallel access in database

It is unclear that the upcoming development of an ISA database which will be implemented within a few years, has any substantial objectives. The database should not be just a platform for data submitted by contractors. To collect new biological data in deep sea, clear objectives to collect some kinds of data and to provide a parallel access to data by stakeholders, such as the CCAMLR system has created for the vulnerable marine environment database, would be effective (see Chapter 4.4) Such a database should allow a parallel access for data submitted by contrators and others who can submit their research findings and other parties with substantial interest in what is known, e.g., observers, NGOs, etc..

D) Real-time or quasi real-time publication and streaming of monitoring data

Information provision should be as fast as possible. ISA should release production reports and pollution status reports quickly as is the case for the US offshore oil and gas monitoring (Chapter 4.5). If real-time monitoring of the environment by any contractors is possible, such monitoring pictures and video should be streamed on the ISA websites. The real-time streaming of monitoring data can have a function of monitoring and reporting by third parties. Such efforts to make information accessible to interested parties is consistent with the CHM principles as well.

5.2.7. Confidentiality

A) Decision making by other than the Secretary-General for confidentiality

The current regulations give all decision making power with respect to data confidentiality to the Secretary General upon consulting with contractors (see Table 3.1, 3.2; Confidentiality row), which produces transparency issues (Ardron et al., 2018). It could also cause inequity issues among contractor as many contractors have already expressed the concerns (Appendix A). Establishment of criteria for what constitutes proprietary data as well as powers to assess such confidentiality should be reconsidered and spread, e.g., with establishment of a compliance committee.

5.3. Technological arrangement options

In Chapter 3.3, I expressed the viewpoint that there is some urgency involved in establishing baseline monitoring to understand the deep seabed environment and to complete acquisition of baseline data before commercial mining starts. However, it was also evident that the current ISA regulations and guidelines lack such a perspective in its list of technologies.

In review of the monitoring requirements for the purpose of the environmental impact assessment (EIA) of mining, it became clear that to detect, and measure and record the properties of discharge and operational plumes generated by mining may well be the most important near-term activity to create well-designed impact assessments, and that the higher resolutions in both space and time scales might be essential. Yet, it was found that the ISA regulations do not even provide advice on requirements except for the ambiguous call to use "good industry practices".

In this section, taking into account of the examination in Chapter 3.3, the current and future technologies and the institutional recommendations in Chapter 5.1, I discuss technological options that could improve the ISA's effectiveness for baseline monitoring and requirements for EIA monitoring, respectively.

5.3.1. Baseline monitoring

A) Define baseline monitoring strategies with spatial and temporal resolution in key areas (e.g. narrowing-down from the larger scale observation)

For the scientific goal to document natural environmental variations in the whole CCZ area, the scale of the current ISA's baseline monitoring (each contractor monitors in each contracted area) is too small and focuses only on the seabed close to mining areas. Each contractor's data would be reported using different methods and have various measurement errors, and observation stations would not be systematic. Summarizing these fragmented data would be difficult and not efficient. ISA should create an observation strategy which should be ordered from the larger scale measurements to smaller scale measurements. This would involve referencing earlier deep sea monitoring.. With respect to large scale measurement, ISA should consider the collective employment of contractors to survey as a large as possible area in the CCZ beyond each contracted area. The implementation of this recommendation can be incorporated with the collective monitoring and reporting (Recommendation 5.2.2A) and the ISA managed reporting (Recommendation 5.2.2B).

First, ISA's seven baseline categories (Table 3.3) should be prioritized and ordered in the observation. I suggest the measurement of physical, chemical and sediment transport categories should be conducted earlier and separate from other categories because they will most likely drive other categories such as benthic community health and resilience. These initial background monitoring categories should be assessed across the entire CCZ scale with well-planned vessel observation stations and mooring locations.

Second, ISA should determine the measurement targets with spatial and temporal scales for each category (Table 5.1). In physical oceanography, for example, ocean currents assessments should distinguish the mean ocean currents, small scale eddies and topographic flows (<1-100 km ~ the scale of each ISA contracted area). They should also include the different flow regimes among layers (e.g. near bottom, bottom to 2500 m depths, 2500 to 1000 m depths, 1000 to 200 m depths, and 200 m to surface waters). The mean current analysis needs 1-day resolution with about 2-year long data collection period at least, but topographic small-scale flows would need < 1 day measurements to resolve for tidal frequencies. An analysis of the effects by El Nino or La Nina will require decadal scale data collection. To establish a baseline for the ongoing monitoring strategy, in the first two years, contractors' focus on CTD measurements by vessels at planned stations and deployment of current-meter moorings at selected points to define the mean currents in deep layers should be implemented. Then, in the next years, as mining begins, monitoring approaches should be able to move on to the smaller scale observations to detect topographic currents in each contracted area. The environmental assessment teams should also employ computer simulations to confirm and extend the observational results to all scales that area appropriate. Such a strategy would specify time scales and clear measurement goals to contractors and help completing and utilizing baseline monitoring effectively. With this plan, the basic physical oceanographic baseline could be completed within about two-three years.

Table 5.1. An example of the baseline monitoring strategy in the CCZ. A consideration based on Chapter 3.3 by the thesis author.

Monitoring targets	Expected spatial variations	Expected temporal variations	Monitoring strategies
Currents	Mean currents in the CCZ scale and each layer (bottom, bottom-2500m, 2500-1000m, 1000-200m, 200-0m) Small scale and topographic flows (<~100km) in a contracted area	A couple of years affected by e.g. El Nino Several months 6 hours ~ several days	For the first 2 years ① Vessel observations at every 1degree stations to measure currents and water properties for the mean spatial and temporal features ② Analysis of deep water masses ③ Analysis of the mean deep currents ④ Deployment of current-meter mooring to obtain the temporal variability ⑤ Analysis of the surface currents with data of Argo floats and satellites ⑥ Analysis of the mean intermediate currents Next years ① Vessel observations of small topographic flows at key locations in a contracted area ② Current-meter mooring at key locations in a contracted area ③ Simulation models to confirm and predict flows in a contracted area Within a decade ① Accumulation of data for the analysis of long-term variations
Chemicals	Advection by water masses Effects by natural sources from e.g. hydrothermal activities	Similar to the currents Effects by natural sources	For the first 2 years ① Water sampling by vessels along to the currents observations ② Extra observations to define natural sources from hydrothermal plumes
Sedimentation rates	Primary production spatial variation at the sea surface Advection by water masses	Seasonal ~ yearly variations by primary production (e.g. El Nino) Effects by water mass variation (several months)	For the first 2 years ① Analysis of primary production with satellite data ② Deployment of sediment trap mooring to obtain the temporal variability at every 5 degrees Next years ① Deployment of sediment trap mooring at key locations in each contracted area to obtain smaller scale variability Within a decade ① Accumulation of data for the analysis of long-term variations

B) Prioritize areas for biological surveys

Biological surveys (Baseline category of Benthic and pelagic fauna in Table 3.3; Chapter 3.3) would need a different strategy to obtain data, and more observation time is required because of the nature of biological sampling. Prioritization of the area for the biological baseline survey is important. The priority should take into account the biological habitat knowledge in the whole CCZ, and ideally the observation should be conducted from the larger scale by collective monitoring by contractors as a requirement of ISA.

5.3.2. EIA monitoring during mining

A) Define discharge and operational plumes (i.e., particle size or substances)

Discharge and operational plumes are the ISA's most important monitoring target in future mining, however, I observe in Chapter 3.3 ISA does not have quantitative definitions of acceptable limits for discharge of sediments from operational plumes. The ISA should make guidelines for such plumes including definitions in particle size and quantity of substances based on earlier studies and data (e.g., Papua New Guinean EEZ mineral mining; (Coffey Natural Systems, 2008). Without this criterion, contractors could not monitor and assess the plumes effectively, and the monitoring outcomes would be ambiguous.

B) Achieve high spatial and temporal resolutions of plume monitoring with advanced technologies (i.e. independent monitoring system consisting of AUVs and seafloor stations with compact and mountable sensors)

The ISA does not provide sufficient instruction on how to detect plumes. I believe that one effective method may involve an AUV-seafloor station system to monitor water-column plumes in high resolution. Such a system has to operate in close to real-time and have capacities to monitor the plume comprehensively so that even a plume intrusion to an adjacent contract areas can be detected (e.g., Germany; Appendix A). For the polymetallic sulfide mining in the Papua New Guinean EEZ, Gordon (2016) proposes the ideal AUV monitoring of mining plumes using a docking station connected to a seafloor cable for power supply and data transmission (Fig. 5.1). Because of the cost of laying cables from land to the CCZ, I propose to use seafloor AUV stations charged by a ship instead of by a seafloor cable. A prototype of such a seafloor station for shallower waters has been recently developed

(Maki, Sato, Matsuda, Masuda, and Sakamaki, 2018). Compared to the normal ship-based operational method to deploying and recovering AUVs from a ship, the seafloor installed AUV station approach can significantly reduce the vertical transit time and operational costs. For instance, the ship-based method takes about 4 hours for the AUV's round-trip between the ship and the 5000m-depth seabed daily, in addition to the need for careful operations which must maneuver the AUV when it is near the surface and recovered to the deck of the ship. The seafloor station-based method requires the development of power charging technology at the seafloor station and data transmission capability. It could be possible to use a wire cable connection from a ship periodically for this purpose so that the ship does not have to be on site continuously.

One advantage of this system would be in its independence from the actively mining ship or the ore barge. For example, the Japanese government has adopted the ROV and mooring system for plume monitoring in the EEZ mineral mining, which might be applied to its mining in the ISA contracted areas as well (Japan Ministry of Economy, Trade, and Industry, 2018). But the Japanese method cannot monitor plumes close to the mining operation because of the need to protect the ROV tether cable from entanglement with the operational facilities such as riser pipes, and to secure the monitoring moorings.

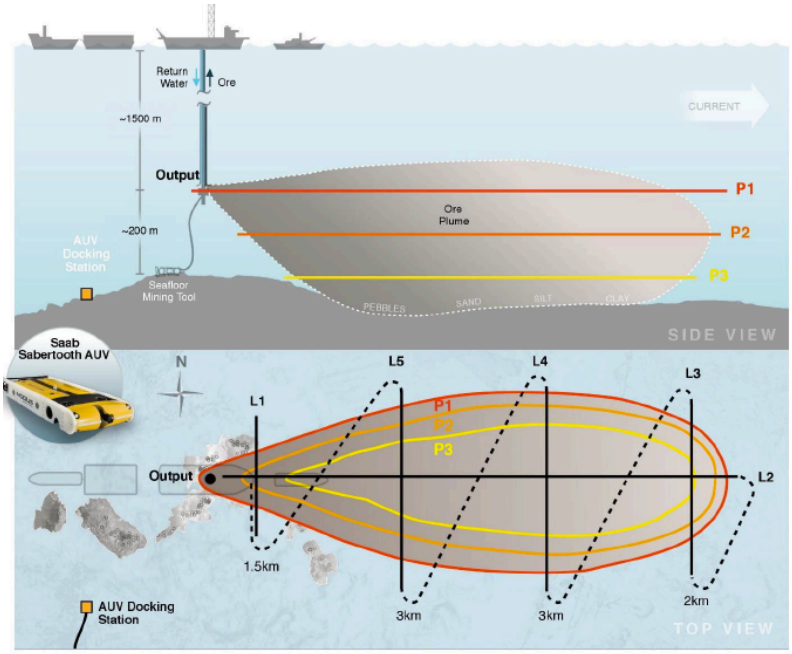

Figure 5.1. Mining plume monitoring with the AUV-seafloor cable system. (Gordon, 2016).

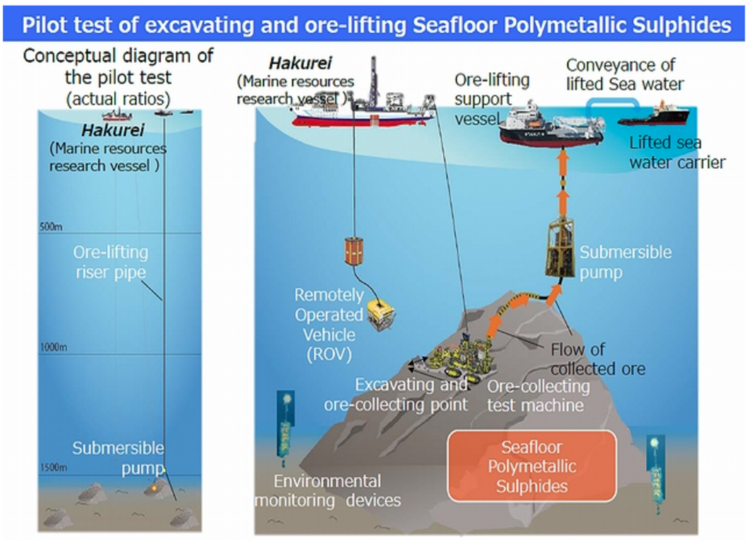

Figure 5.2. Japanese monitoring methods for deep sea mining of polymetallic sulfides in the EEZ (Japan Ministry of Economy, Trade and Industry, 2018).

C) Keep recoding biological photos both in and outside of mining areas

Benthic community photos are also components of baseline monitoring. Photographic or video surveys should be continuous during the mining period in selected areas to track how large benthic species are impacted by mining and visually trace the species as far and as long as possible.

D) Establish funding and projects to develop specialized deep seabed monitoring technologies

Deep seabed monitoring during mining such as described in the proposal B needs very special technologies, which tolerate high water pressure, supply long battery life or battery base, and develop capacities to conduct multiple categories of sampling with less costs. Such technologies are different in goals and functions from those for shallow water monitoring e.g. long-range AUV operations under sea ice (National Oceanography Centre, n.d.). An EU research group reviewed the technological readiness for future deep sea mining from the state of the art of deep sea monitoring technologies (MIDAS, 2015). This research suggests that only 18 out of 42 technologies have matured to the point they can be implemented. The special R&D program for establishing autonomous inspection methods onboard facilities should also be developed (e.g., Algeria and Japan comments in Appendix A).

Table 5.2. Summary of the recommendations to ISA.

Institutional options (19)	What is monitored	Clear goals based on the priority
		Clear common standards and measures among contractors
	Reporting	Collective monitoring and reporting of the environmental data
		ISA managed monitoring and reporting of the environmental data
		Other-reporting system for compliance and emergency issues
	Review	Compliance review committees inside ISA
		Environmental review committees inside ISA
		Analysis and evaluation of contractors' data by ISA or the third party
	Monitoring enforcement	Inspections based on technical standards
		Autonomous transmission of compliance data from mining ships
		Boundary enforcement
	Enforcement and Penalties	Clear criteria and multiple divisions in enforcement and penalty assessments
		A rating system of contractors
		A grace period of amended regulations for good contractors
	Access to information	Transparent access to ISA workshops
		Compliance status and meeting documents
		Parallel access in database
		Real-time or quasi real-time publication and streaming of monitored data
	Confidentiality	Decision making by other than the Secretary-General for confidentiality
Technological options (6)	Baseline monitoring	Define baseline monitoring strategies with spatial and temporal resolution in key areas (e.g. narrowing-down from the larger scale observation)
		Prioritize areas for biological surveys
	Impact monitoring	Define discharge and operational plumes (i.e., particle size and substances)
		Achieve high spatial and temporal resolutions of plume monitoring with advanced technologies (i.e. independent monitoring system consisting of AUVs and seafloor stations with compact and mountable sensors)
		Keep recording biological photos both in and outside of mining areas
		Establish funding and projects to develop deep seabed monitoring technologies

Chapter 6. Concluding remarks

Deep seabed mining has been regulated by the ISA since the UNCLOS entered into force in 1994, and now the ISA is establishing the regulations for commercial mining. This thesis examines the ISA's developing environmental monitoring system for the exploration and exploitation of polymetallic nodules in the CCZ from the perspectives of transparency and effectiveness. The analysis of monitoring in the current and proposed mining regulations (Chapter 3) shows that the ISA monitoring system relies on the direct instruments of conventional enforcement and penalties only between the authority and individual contractor for issues of non compliance, and that the system lacking transparent review because the low capacities of data access by stakeholders. Many uncertainties in monitoring and reporting requirements including compliance bring about confusion and feelings of inequity among some stakeholders.

Based on the comparative case study analysis with other deep sea monitoring practices in Chapter 4, the current ISA monitoring system is similar to national practices such as the US offshore oil and gas production monitoring in the EEZ. However, most international institutions such as the Barcelona Convention's offshore industry monitoring are now focusing on collective regional monitoring and transparent reporting. The review systems achieve the higher monitoring effectiveness collectively among member states, which represents a significant shift from the national type of monitor. These results from the case studies raise the issue of whether the ISA's approach to monitoring mining operations might not be sufficiently adaptive in managing the unknown mining impacts to the deep sea environment in a large area such as the CCZ. This question remains despite the fact that the ISA states in its regulations that they regard adaptive management as very important.

Taking into account the foregoing examinations, I propose concrete policy recommendations that would allow the ISA to improve the design of current monitoring systems to become more transparent and effective in Chapter 5 (Table 5.2). The key areas to improve are in detecting non-compliance, improving the efficiency of efforts to obtain environmental data, and the balance between transparency and the confidentiality for contractors. Especially with respect to the reporting system, I emphasize that it is necessary that a collective monitoring team comprised of adjacent Area contractors or of the ISA itself, be tasked with monitoring the large contiguous area of adjacent claims and report environmental data to all in a consistent and transparent manner, thereby improving the efficiency and effectiveness of the entire monitoring effort.

In addition to monitoring, there are many issues to be addressed in the ISA system as it stands. These items include questions of how to deal with accidents that may occur to the seafloor pipelines or cables transiting the areas of interest, or inequity issues such as technology transfers from developed nations to developing nations which the UNCLOS stipulates, but has not been discussed. ISA does not seem to have sufficient capacity or does not have mature mechanisms to address these issues based on their current publications. However, once the exploitation regulations are approved and passed, it may be difficult to stop the commercial mining and to condition it with adequate monitoring protocols. ISA should take enough time and increase its capacities to examine every issue of concern brought forward by stakeholders before the regulations become agreed upon. Commencement of mining can and certainly should wait until ISA completes its deliberations.

Addendum

ISA's development of monitoring arrangements for seabed exploitation are a moving target. This thesis is current to May 15, 2018. Since that time ISA has issued an update Draft Regulations on Exploitation of Mineral Resources in the Area (ISBA/24/LTC/WP.1; ISA, 2018c). This document is not included in the research and analysis done for this thesis. A cursory review indicates that some of the issues raised in this thesis are partially addressed by the continuing development of monitoring requirements by ISA. Still, it appears that most of the analysis and recommendations of this thesis remain valid to inform future development of ISA's monitoring system for deep seabed mining.

Appendix A. Summary of the ISA stakeholder opinions regarding monitoring.

In 2017 August, ISA made publicly available the draft regulations and invited public comments (ISBA/23/C/12). In 2018 February, ISA published the public comment reports from stakeholders (ISA, 2018a). Here, I examine the reports and summarize in this Table with respect to monitoring elements of selected stakeholder responses.

Table A: Summary of the ISA stakeholder opinions regarding monitoring. Blue: member states; orange: contractors; and other stakeholders such as science groups, industry groups and NGOs.

	Stakeholder	Clearer definitions in the monitoring regulations	Protection of Contractor's rights	Contractors and State obligations	ISA obligations	Public consultations	Access to Info and Confidentiality	Inspections
	Germany	* Distinguish between Contract area from Exploration area * Term 'Environmental information' should be defined, e.g., the Aarhus Convention.		* An independent and legally binding scientific monitoring strategy, conducted by third parties, to validate the environmental impact. * Authorized test mining.	*Plume's effects from other contracted areas should be considered.	*Public participation should not be restricted to the scoping and EIA process. *Interested persons are too narrow.	* Confidential information should be protected. *Environmental information should be published.	
	Japan	* Clear standards for "reasonable regard" should be established in the "guidelines". * Criteria of the times of public consultants and scope of Interested persons.	* The regulations should not impair the principle of the freedom of the high seas.		* Scientific evidence is necessary for LTC comments. * Identification of breach and remedial actions to follow shall be decided by the Council based on LTC recommendations.			* Inspection not regularly but when deemed necessary to reduce costs. * Less cost methods of inspectors' appointment. * Sponsoring states' participation in

								inspections.
	African group (Algeria)	*Clarification of the responsibilities between States and ISA for enforcement, monitoring, info-sharing coordination. * Clarification of ISA inspection details. * Clarification of confidential information and evaluation methods. * Clarification of consultation by interested persons.		* Regional Environmental Monitoring Plan.	*The Council needs more information such as plans and application documents. *Before introducing new monitoring and inspection technology (acoustic, satellite, electronic), ISA should foresee how it would improve inspection efficiently.	* Wider public consultation than interested persons is needed. * Data on EIS and scoping report should be available to interested persons.	* Publish all non-confidential information and reports to improve transparency.	
	Mexico			* Highly migratory species protection as a responsibility of the States. *Baseline data should be submitted with an exploitation application.			* Baseline data should be published.	
	Korea	*Clarification of procedures of the Contractor's Environmental performance review and Monitoring Plan's compliance review.						
	Inter Ocean Metal Joint Organizatio n (East European)				* ISA should create ISA's own reporting system on marine science research and exploitation activities.			*Contractors should not pay inspection fees.

Global Sea Mineral Resources NV (Belgium)	*Clarify that contractors may not conduct exploration surveys during exploitation.	* Contractors can revise Plans.		* The Council should not suspend contractor's mining activities in the event of a termination of sponsorship.	* Interested persons should be identified * Public consultations should not impede facilitating the plan's approvals.	* Plans should be published on ISA websites. * Confidential info defined by the SG will produce power to the SG, which might cause inequality of sponsoring states' laws and contractors.	
China Ocean Mineral Resources R&D Association (China)	* Confidential information should be determined by reasonable basis. * Details of 'Plans of Work'. * Definitions of Areas.	* Protection of contractors rights. * Contractors can use their contract to secure financing.		* ISA's obligations e.g., coordination with other organizations and rules.		* Contractors have priority for confidential information.	
China Minmetals Corporation (China)		* Regulations should consider market rules and economic efficiency. * Protect contractors' interest and rights. * Regulations should reference land mining rules and experience.					
US SR Ltd (UK)	* Confidential information criteria.	* Regulatory certainty for investment.		* Do not make any advantages among contractors.			
DORD (JAPAN)	*A template for monitoring results. * Environmental standards and evaluation methods. * Clarification of environmental monitoring systems.	* Regulation revisions (every 5 years) should not affect on-going exploitation.		* ISA should organize public consultations for EIS and Environmental Scoping Report instead of applicants. * ISA should ensure that no other entity interfering with the		* Confidential info expiration period should be discussed with the SG and Contractors after 10 years.	* Inspection should not be at all contractor's costs.

				operations of the contractor. * A mechanism to avoid unlawful obstruction to mining activities.			
IFREMER (France)	* Annual report's key topics and details. * "Environmental Impact Area" is ambiguous and needs monitoring to be determined.		* Contractors should make and publish a report to answer the EIS review comments by Interested persons and SG.			* Access to data and info should be legally binding.	
JOGMEC (Japan)	* Clarification of the effective protection methods of the marine environment. * E-monitoring functions should be specified. * Clarification of monitoring details in order to create feasibility-study and closure plans.					* Information disclosure provisions are too excessive compared to land mining. *Confidential info should not have the 10 year expiration period.	
MRE Ltd (Kiribati)	* Clarify the difference between regulations and recommendations.	* Regulations should be timely and commercially viable. * Mutual consent before a contract and regulations are revised to secure financing, e.g., fees. * Revisions affect only new contractors. * Flexible production, i.e., no suspension and reducing production rate. * Organizations to		* Regulation updating should be less frequently (more stability to secure financing). * Environmental Scoping Report should not be included in the exploitation regulations (Delay may cause problems). * ISA should track the record of mining jurisdiction.			

			support contractors to improve operations.					
	ICPC			* Due regard to cable owners and contractors. * Information exchange with cable owners to avoid conflicts before mining. * Immediate notification of attaching to cables to cable owners. * Any cable data should be taken as confidential.	* There is freedom of laying cables and to maintain cables even in contract areas.			
	International Maritime Organizatio n				* Waste Assessment Guidelines of London Dumping Protocol would be mutual beneficial with IMO and ISA.			
	Deep Sea Conservatio n Coalition	* EIS needs clarify the areas to be protected and monitored which should not be limited to PRZ and IPZ. * Comprehensive list of information that should be considered non-confidential in a non-exhaustive list.		* Independent expert review should add to the compliance and performance review process. * EIS needs independent scientific assessments. * Environmental performance review should assess the effectiveness (currently only compliance) with independent expert review or public review. * Any contract should be amended according to a review to protect the environment.		* Public consultant should be required (not encouraged). * Stakeholder should be used instead of Interested persons and open-ended (should not be narrowed down).	* Public access to environmental data, meta data, the LTC Commission's comments on plans and reports. * Access to information should be required (not encouraged).	

	Pew Charitable Trust	*Environmental goals, standards, thresholds are not clear. * Disorganized standards for non-compliance and penalties. * Multiple sponsorships' termination causes any legal responsibilities.		* Strategic or regional environmental management plans (REMPs). * Contractors should monitor the entire impact area not only mining areas, and multiple sites inside/outside the impact area. (environmentally vulnerable area too). * Environmental performance review needs independent scientific review	* ISA-led stakeholder engagement to organize among states, which includes public and scientific review.	* Stakeholder should be used instead of interested persons and should be open-ended.	* Confidentiality needs the rationale.	* Sponsoring states need independent inspections and access to ISA inspections.
	Deep Ocean Stewardship Initiative	* Lack of definitions of environmental protection matters such as "reasonable and practical measures" and "contract area".			* ISA should address the lack of explicit availability of experts to the LTC.	* External review by appropriate experts of applications and documents are needed. * Public consultations by Interested Persons are very limited.	* Confidentiality should be defined more clearly and listing the criteria. * More transparent process to review the confidentiality.	
	Deep Sea Mining Alliance / Voice of German Industry	* list of confidential data *a clear distinction of the player's roles in monitoring	*Periodic review of plans should not automatically amend the terms of an existing contract.	*Independent monitoring by independent experts and service providers.	*ISA should establish auditing procedures over national mining legislations.	*Interested persons should be narrowed down to those whom directly affected by DSM such as people living in the area and scientists with a record of pertinent research.	* All environmental data should be open access. *Prescribe the protection method of contractors' confidential data.	*Unannounced inspections

	DNV/GL Norway	*Clarification of the difference between mining areas and contracted areas *Clarification whether exploration has to be conducted during exploitation * Clarifications of monitoring (Who, how, what)		* Regulations should be applied for national regulatory systems.	* Regulations on environmental aspects and hazard identifications is needed to identify accidental and operational impacts.		* Environmental data should not be confidential. * Mutual agreement of the confidential data list between ISA and contractors.	* Unannounced inspections with at least 2 inspectors

References

AMC Consultants Pty Ltd. (2016). Technical Report TOML Clarion Clipperton Zone Project, Pacific Ocean, 280.

American Oil and Gas History Society. (2017, November 12). Offshore Petroleum History. Retrieved March 12, 2018, from https://aoghs.org/offshore-history/offshore-oil-history/

Ardron, J. A. (2016). Transparency in the operations of the International Seabed Authority: An initial assessment. Marine Policy. https://doi.org/10.1016/j.marpol.2016.06.027

Ardron, J. A., Ruhl, H. A., & Jones, D. O. B. (2018). Incorporating transparency into the governance of deep-seabed mining in the Area beyond national jurisdiction. Marine Policy, 89, 58–66. https://doi.org/10.1016/j.marpol.2017.11.021

Baur, D. C., Eichenberg, T., Snusz, G. H., & Sutton, M. (2015). Ocean and Coastal Law and Policy (2nd ed.). American Bar Association.

Beaulieu, S. E., Graedel, T. E., & Hannington, M. D. (2017). Should we mine the deep seafloor?, Earth’s Future, 5(7), 655–658. https://doi.org/10.1002/2017EF000605

BOEM. (2017). BOEM Environmental Studies Program - Strategic Framework. Retrieved April 18, 2018, from https://www.boem.gov/Strategic-Framework-2017/

BOEM. (n.d.). Reforms since the Deepwater Horizon Tragedy. Retrieved April 18, 2018, from https://www.boem.gov/Reforms-since-the-Deepwater-Horizon-Tragedy/

Bradley, M., & Swaddling, A. (2016). Addressing environmental impact assessment challenges in Pacific island countries for effective management of deep sea minerals activities. Marine Policy. https://doi.org/10.1016/j.marpol.2016.06.017

BSEE. (2016a). BSEE annual report 2016. Retrieved April 18, 2018, from https://www.bsee.gov/sites/bsee.gov/files/bsee_2016_annual_report_v6b.pdf

BSEE. (2016b). Real-Time Monitoring (RTM) | Bureau of Safety and Environmental Enforcement. Retrieved April 18, 2018, from https://www.bsee.gov/what-we-do/offshore-regulatory-programs/emerging-technologies/Real-Time-Monitoring-RTM

BSEE. (n.d.-a). Best Available and Safest Technologies | Bureau of Safety and Environmental Enforcement. Retrieved March 12, 2018, from https://www.bsee.gov/what-we-do/offshore-regulatory-programs/emerging-technologies/BAST

BSEE. (n.d.-b). Environmental Focuses | Bureau of Safety and Environmental Enforcement. Retrieved April 17, 2018, from https://www.bsee.gov/what-we-do/environmental-focuses

BSEE. (n.d.-c). How are pollutant releases or discharges discovered and reported? | Bureau of Safety and Environmental Enforcement. Retrieved April 18, 2018, from https://www.bsee.gov/faqs/how-are-pollutant-releases-or-discharges-discovered-and-reported

CCAMLR. (2009). VME Taxa Classification Guide | CCAMLR. Retrieved April 14, 2018, from https://www.ccamlr.org/en/document/publications/vme-taxa-classification-guide

CCAMLR. (2014). CCAMLR Ecosystem Monitoring Program Standard Methods | CCAMLR. Retrieved April 16, 2018, from

https://www.ccamlr.org/en/document/publications/ccamlr-ecosystem-monitoring-program-standard-methods
CCAMLR. (2017). Report of the Thirty-Sixth Meeting of the CCAMLR Commission. Retrieved from https://www.ccamlr.org/en/system/files/e-cc-xxxvi_0.pdf
CCAMLR. (n.d.-a). Online GIS | CCAMLR. Retrieved April 16, 2018, from https://www.ccamlr.org/en/data/online-gis
CCAMLR. (n.d.-b). Vulnerable Marine Ecosystems (VMEs) | CCAMLR. Retrieved April 14, 2018, from https://www.ccamlr.org/en/science/vulnerable-marine-ecosystems-vmes
Coffey Natural Systems. (2008). Environmental Impact Statement Solwara 1 Project.
Collins, P. C., Croot, P., Carlsson, J., Colaço, A., Grehan, A., Hyeong, K., … Rowden, A. (2013). A primer for the Environmental Impact Assessment of mining at seafloor massive sulfide deposits. Marine Policy, 42, 198–209. https://doi.org/10.1016/j.marpol.2013.01.020
Davidson, H., & Doherty, B. (2017, December 11). Troubled Papua New Guinea deep-sea mine faces environmental challenge. The Guardian. Retrieved from http://www.theguardian.com/world/2017/dec/12/troubled-papua-new-guinea-deep-sea-mine-faces-environmental-challenge
Deep Sea Mining Campaign. (2015). Accountability ZERO -A critique of the Nautilus Minerals environmental and social benchmarking analysis of the Solwara 1 project. Retrieved from http://www.deepseaminingoutofourdepth.org/wp-content/uploads/accountabilityZERO_web.pdf
Deep Sea Mining: Out Of Our Depth |. (n.d.). Retrieved May 27, 2018, from http://www.deepseaminingoutofourdepth.org/
Durden, J. M., Lallier, L. E., Murphy, K., Jaeckel, A., Gjerde, K., & Jones, D. O. B. (2018). Environmental Impact Assessment process for deep-sea mining in ‘the Area.’ Marine Policy, 87, 194–202. https://doi.org/10.1016/j.marpol.2017.10.013
Durden, J. M., Murphy, K., Jaeckel, A., Van Dover, C. L., Christiansen, S., Gjerde, K., … Jones, D. O. B. (2017). A procedural framework for robust environmental management of deep-sea mining projects using a conceptual model. Marine Policy, 84, 193–201. https://doi.org/10.1016/j.marpol.2017.07.002
Ellis, J. I., Clark, M. R., Rouse, H. L., & Lamarche, G. (2017). Environmental management frameworks for offshore mining: the New Zealand approach. Marine Policy, 84, 178–192. https://doi.org/10.1016/j.marpol.2017.07.004
European Commission. (n.d.). Barcelona Convention - Marine - Environment - European Commission. Retrieved March 12, 2018, from http://ec.europa.eu/environment/marine/international-cooperation/regional-sea-conventions/barcelona-convention/index_en.htm
FAO. (n.d.-a). FAO Fishing Vessels Finder. Retrieved April 16, 2018, from http://www.fao.org/figis/vrmf/finder/search/#stats
FAO. (n.d.-b). Vulnerable Marine Ecosystems | Food and Agriculture Organization of the United Nations. Retrieved April 16, 2018, from http://www.fao.org/in-action/vulnerable-marine-ecosystems/en/
Feely, R. A., Baker, E. T., Marumo, K., Urabe, T., Ishibashi, J., Gendron, J., Lebon, G.T., &

Okamura, K. (1996). Hydrothermal plume particles and dissolved phosphate over the superfast-spreading southern East Pacific Rise. Geochimica et Cosmochimica Acta, 60(13), 2297–2323. https://doi.org/10.1016/0016-7037(96)00099-3

Fraser, G. S., Ellis, J., & Hussain, L. (2008). An international comparison of governmental disclosure of hydrocarbon spills from offshore oil and gas installations. Marine Pollution Bulletin, 56(1), 9–13. https://doi.org/10.1016/j.marpolbul.2007.09.032

Ghosh, A. (2017). Vertical lift study for harvesting of seabed minerals for deep sea mining (PhD Thesis).

Global Environmental Facility. (2013, March 4). System for Transparent Allocation of Resources (STAR). Retrieved June 8, 2018, from https://www.thegef.org/documents/system-transparent-allocation-resources-star

Gordon, C. (2016). In Situ Assessment of Initial Seafloor Massive Sulfide Mining Operation in Papua New Guinea Using a Cabled Autonomous Underwater Vehicle System: A Proposition.

Hannington, M., Petersen, S., & Krätschell, A. (2017). Subsea mining moves closer to shore. Nature Geoscience, 10(3), 158–159.

Hein, J. R., Spinardi, F., Okamoto, N., Mizell, K., Thorburn, D., & Tawake, A. (2015). Critical metals in manganese nodules from the Cook Islands EEZ, abundances and distributions. Ore Geology Reviews, 68, 97–116. https://doi.org/10.1016/j.oregeorev.2014.12.011

ISA (Ed.). (2002). Standardization of environmental data and information--development of guidelines: proceedings of the International Seabed Authority’s Workshop held in Kingston, Jamaica 25-29 June 2001. Kingston, Jamaica: International Seabed Authority.

ISA. (2011). Environmental Management Plan for the Clarion Clipperton Zone. Retrieved from https://www.isa.org.jm/sites/default/files/files/documents/isba-17ltc-7_0.pdf

ISA. (2013a). Recommendations for the guidance of contractors for the assessment of the possible environmental impacts arising from exploration for marine minerals in the Area. Retrieved from https://www.isa.org.jm/sites/default/files/files/documents/isba-19ltc-8_0.pdf

ISA. (2013b). Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area, amended. Retrieved from https://www.isa.org.jm/sites/default/files/files/documents/isba-19c-17_0.pdf

ISA. (2015). Recommendations for the guidance of contractors on the content, format and structure of annual reports. Retrieved from https://www.isa.org.jm/sites/default/files/files/documents/isba-21ltc-15_1.pdf

ISA. (2017a). Draft Regulations on Exploitation of Mineral Resources in the Area.pdf (No. ISBA23- LTC-CRP3- Rev). Retrieved from https://www.isa.org.jm/files/documents/EN/Regs/DraftExpl/ISBA23-LTC-CRP3-Rev.pdf

ISA. (2017b, January). A Discussion Paper on the development and drafting of Regulations on Exploitation for Mineral Resources in the Area (Environmental Matters). Retrieved from https://www.isa.org.jm/files/documents/EN/Regs/DraftExpl/DP-EnvRegsDraft25117.

pdf
ISA. (2018a). Briefing note on the submissions to the draft regulations on exploitation of mineral resources in the Area. Retrieved from https://www.isa.org.jm/files/documents/EN/Regs/2018/BNote-Feb2018.pdf
ISA. (2018b, January). SUBMISSIONS TO INTERNATIONAL SEABED AUTHORITY'S DRAFT REGULATIONS ON EXPLOITATION OF MINERAL RESOURCES IN THE AREA. Retrieved March 14, 2018, from https://www.isa.org.jm/files/documents/EN/Regs/2017/List-1.pdf
ISA. (2018c, May). Draft Regulations on Exploitation of Mineral Resources in the Area (prepared by the Secretariat). Retrieved from https://www.isa.org.jm/sites/default/files/files/documents/isba24-ltcwp1-adv.pdf
Jaeckel, A. (2016). Deep seabed mining and adaptive management: The procedural challenges for the International Seabed Authority. Marine Policy, 70, 205–211. https://doi.org/10.1016/j.marpol.2016.03.008
Jaeckel, A., Ardron, J. A., & Gjerde, K. M. (2016). Sharing benefits of the common heritage of mankind – Is the deep seabed mining regime ready? Marine Policy, 70, 198–204. https://doi.org/10.1016/j.marpol.2016.03.009
Jaeckel, A., Gjerde, K. M., & Ardron, J. A. (2017). Conserving the common heritage of humankind – Options for the deep-seabed mining regime. Marine Policy, 78, 150–157. https://doi.org/10.1016/j.marpol.2017.01.019
Japan Ministry of Economy, Trade and Industry. (2018). World's First Success in Continuous Ore Lifting test for Seafloor Polymetallic Sulphides(METI). Retrieved from http://www.meti.go.jp/english/press/2017/0926_004.html
Katsanevakis, S., Levin, N., Coll, M., Giakoumi, S., Shkedi, D., Mackelworth, P., Levy, R., Velegrakis, A., koutsoubas, D., Caric, H., Brokovich, E., Ozturk, B, & Kark, S. (2015). Marine conservation challenges in an era of economic crisis and geopolitical instability: The case of the Mediterranean Sea. Marine Policy, 51(Supplement C), 31–39. https://doi.org/10.1016/j.marpol.2014.07.013
Kawabe, M., & Fujio, S. (2010). Pacific ocean circulation based on observation. Journal of Oceanography, 66(3), 389–403. https://doi.org/10.1007/s10872-010-0034-8
Kawabe, M., Yanagimoto, D., Kitagawa, S., & Kuroda, Y. (2005). Variations of the deep western boundary current in Wake Island Passage. Deep Sea Research Part I: Oceanographic Research Papers, 52(7), 1121–1137. https://doi.org/10.1016/j.dsr.2004.12.009
Lee, C.-H., Kim, H.-W., Choi, J.-S., Yeu, T.-K., Lee, M.-U., Oh, J.-W., & Hong, S. (2014). Study of Deepsea Mining Robot "MineRo" Using Table of Orthogonal Arrays. Journal of Ocean Engineering and Technology, 28(2), 152–159. https://doi.org/10.5574/KSOE.2014.28.2.152
Levin, L. A., Mengerink, K., Gjerde, K. M., Rowden, A. A., Van Dover, C. L., Clark, M. R., … Brider, J. (2016). Defining "serious harm" to the marine environment in the context of deep-seabed mining. Marine Policy, 74, 245–259. https://doi.org/10.1016/j.marpol.2016.09.032
Lodge, M., Johnson, D., Le Gurun, G., Wengler, M., Weaver, P., & Gunn, V. (2014). Seabed mining: International Seabed Authority environmental management plan for the

Clarion–Clipperton Zone. A partnership approach. Marine Policy, 49, 66–72. https://doi.org/10.1016/j.marpol.2014.04.006

Lupton, J. E., & Jenkins, W. J. (2017). Evolution of the south Pacific helium plume over the past three decades: SOUTH PACIFIC HELIUM PLUME EVOLUTION. Geochemistry, Geophysics, Geosystems, 18(5), 1810–1823. https://doi.org/10.1002/2017GC006848

Maki, T., Sato, Y., Matsuda, T., Masuda, K., & Sakamaki, T. (2018). Docking Method for Hovering-Type AUVs Based on Acoustic and Optical Landmarks, 10.

MIDAS. (2015). MIDAS Compilation of existing deep-sea ecosystem technologies in European research and industry sectors: Assessment of applicability and identification of gaps. Retrieved from http://www.eu-midas.net/sites/default/files/deliverables/D10-1_FINAL_lowres.pdf

MiningWatch Canada | Changing public policy and mining practices to ensure the health of individuals, communities and ecosystems. (n.d.). Retrieved May 27, 2018, from https://miningwatch.ca/

Mitchell, R. B. (1998). Sources of transparency: information systems in international regimes. International Studies Quarterly, 42(1), 109–130.

Morrison-Saunders, A., Arts, J., Baker, J., & Caldwell, P. (2001). Roles and stakes in environmental impact assessment follow-up. Impact Assessment and Project Appraisal, 19(4), 289–296. https://doi.org/10.3152/147154601781766871

Morrison-Saunders, A., Marshall, R., & Arts, J. (2007). EIA follow-up: international best practice principles.

National Oceanography Centre. (n.d.). Autosubs. Retrieved June 8, 2018, from http://noc.ac.uk/facilities/marine-autonomous-robotic-systems/autosubs

Nautilus Minerals. (2018a). Preliminary Economic Assessment of the Solwara Project, Bismarck Sea, PNG (p. 274).

Nautilus Minerals. (2018b). Press release: Nautilus Successfully Progressing Trials in PNG. Retrieved April 16, 2018, from http://www.nautilusminerals.com/irm/PDF/1958_0/NautilusSuccessfullyProgressingTrialsinPNG

Nautilus Minerals Inc. (n.d.). Nautilus Minerals. Retrieved May 12, 2018, from http://www.nautilusminerals.com/IRM/content/default.aspx

New York Times. (2017, October 5). New Species of Sponges Found on the Pacific Seafloor. The New York Times. Retrieved from https://www.nytimes.com/2017/10/05/science/sponges-species-pacific-ocean.html

NIWA. (2017). National Institute of Water & Atmospheric Research Ltd 301 Evans Bay Parade, Greta Point Wellington 6021 Private Bag 14901, Kilbirnie Wellington 6241 New Zealand, 105.

OSPAR. (2009). Overview assessment of implementation of OSPAR Recommendation 2006/3 on environmental goals for the discharge by the offshore industry of chemicals that are, or contain, substances identified as candidates for substitution.

OSPAR. (2010). The North-East Atlantic Environment Strategy Strategy of the OSPAR Commission for the Protection of the Marine Environment of the North-East Atlantic 2010–2020. Retrieved October 29, 2017, from

https://www.ospar.org/site/assets/files/1200/ospar_strategy.pdf#page=19
OSPAR. (2014). OSPAR Joint Assessment and Monitoring Programme (JAMP) 2014–2021.
OSPAR. (2016). OSPAR Coordinated Environmental Monitoring Programme (CEMP).
OSPAR. (2017). OSPAR Guidelines for Monitoring the Environmental Impact of Offshore Oil and Gas Activities.
OSPAR. (n.d.). Ecosystem Approach. Retrieved April 11, 2018, from https://www.ospar.org/about/principles/ecosystem-approach
OSPAR Commission | Protecting and conserving the North-East Atlantic and its resources. (n.d.). Retrieved October 22, 2017, from https://www.ospar.org/
PNG. (2000). Enironment Act 2000. Retrieved from http://www.mra.gov.pg/Portals/2/Publications/Enironment%20Act%202000.PDF
PNG. (2014). Environmental Act 2014 (amend). Retrieved from http://www.parliament.gov.pg/uploads/acts/14A_10.pdf
Portman, M. E., Notarbartolo-di-Sciara, G., Agardy, T., Katsanevakis, S., Possingham, H. P., & Di-Carlo, G. (2013). He who hesitates is lost: Why conservation in the Mediterranean Sea is necessary and possible now. Marine Policy, 42, 270–279. https://doi.org/10.1016/j.marpol.2013.03.004
Ramos, T. B., Caeiro, S., & de Melo, J. J. (2004). Environmental indicator frameworks to design and assess environmental monitoring programs. Impact Assessment and Project Appraisal, 22(1), 47–62.
Reporting Templates | International Seabed Authority. (n.d.). Retrieved March 27, 2018, from https://www.isa.org.jm/reporting-templates
Service (KOCIS), K. C. and I. (n.d.). New underwater mining technology pulls up more ore : Korea.net : The official website of the Republic of Korea. Retrieved March 7, 2018, from http://www.korea.net/NewsFocus/Sci-Tech/view?articleId=131977
The mining code | International Seabed Authority. (n.d.). Retrieved January 22, 2018, from https://www.isa.org.jm/mining-code
Tonga Offshore Mining Ltd-Golder Associates. (2012, September). Technical Report: Clarion-Clipperton Zone Project, Pacific Ocean.
UNEP MAP. (1994). Offshore Protocol.
UNEP MAP. (2012). Action Plan to implement the Protocol of the Barcelona Convention concerning the Protection of the Mediterranean Sea Against Pollution Resulting from Exploration and Exploitation of the Continental Shelf and the Seabed and its Subsoil. Retrieved from http://wedocs.unep.org/bitstream/handle/20.500.11822/7313/12ig20_8_annex2_20_12_eng.pdf?sequence=1&isAllowed=y
UNEP MAP. (n.d.). The Mediterranean Action Plan | UNEPMAP. Retrieved April 10, 2018, from http://web.unep.org/unepmap/who-we-are/mediterranean-action-plan
UNEPMAP. (1995). Amendments to the Convention for the Protection of the Mediterranean Sea against Pollution, Barcelona, June 1995.
UNEPMAP. (2016a). Mediterranean Offshore Action Plan in the framework of the Protocol for the Protection of the Mediterranean Sea against Pollution resulting from Exploration and Exploitation of the Continental Shelf and the Seabed and its Subsoil. Retrieved November 13, 2017, from

https://wedocs.unep.org/rest/bitstreams/8381/retrieve
UNEPMAP. (2016b). Mediterranean Offshore Action Plan in the framework of the Protocol for the Protection of the Mediterranean Sea against Pollution resulting from Exploration and Exploitation of the Continental Shelf and the Seabed and its Subsoil. Retrieved November 20, 2017, from https://wedocs.unep.org/bitstream/handle/20.500.11822/6099/16ig22_6_eng.pdf?sequence=1&isAllowed=y
UNEPMAP. (2017a). First Meeting of the Barcelona Convention Offshore Oil and Gas Group (OFOG) Sub-Group on Environmental Impact of Offshore Monitoring Programmes. Retrieved November 13, 2017, from https://wedocs.unep.org/bitstream/handle/20.500.11822/21486/17wg434_9_engonly.pdf?sequence=1&isAllowed=y
UNEPMAP. (2017b). INTEGRATED MONITORING AND ASSESSMENT PROGRAMME OF THE MEDITERRANEAN SEA AND COAST AND RELATED ASSESSMENT CRITERIA. Retrieved November 13, 2017, from https://wedocs.unep.org/bitstream/handle/20.500.11822/17012/imap_2017_eng.pdf?sequence=5&isAllowed=y
UNEPMAP. (n.d.). Compliance Procedures and Mechanisms under the Barcelona Convention and its Protocols. Retrieved November 13, 2017, from https://wedocs.unep.org/bitstream/handle/20.500.11822/368/brochure_compliance_enga5.pdf?sequence=3&isAllowed=y
USCG. (n.d.). USCG National Response Center Home Page. Retrieved April 18, 2018, from http://www.nrc.uscg.mil/
Van Dover, C. L., Ardron, J. A., Escobar, E., Gianni, M., Gjerde, K. M., Jaeckel, A., … Pendleton, L. (2017). Biodiversity loss from deep-sea mining. Nature Geoscience, 10(7), 464–465.
Van Dover, C. L., Arnaud-Haond, S., Gianni, M., Helmreich, S., Huber, J. A., Jaeckel, A. L., … Yamamoto, H. (2018). Scientific rationale and international obligations for protection of active hydrothermal vent ecosystems from deep-sea mining. Marine Policy, 90, 20–28. https://doi.org/10.1016/j.marpol.2018.01.020
Van Dover, C. L. (2011). Tighten regulations on deep-sea mining. Nature, 470(7332), 31–33. https://doi.org/10.1038/470031a
Van Dover, C. L., Arnaud-Haond, S., Clark, M. R., Smith, S., Thaler, A. D., & Hove, S. Van Den. (2016). Application of Biological Studies to Governance and Management of the Deep Sea. In Biological Sampling in the Deep Sea (pp. 404–430). Wiley-Blackwell. https://doi.org/10.1002/9781118332535.ch18
Wakefield, J. R., & Myers, K. (2016). Social cost benefit analysis for deep sea minerals mining. Marine Policy. https://doi.org/10.1016/j.marpol.2016.06.018
Wood, M. C. (1999). International Seabed Authority: The First Four Years. Max Planck Yearbook of United Nations Law, 3, 173–242.
Workshop: Design of Impact Reference Zones and Preservation Reference Zones in the Area | International Seabed Authority. (n.d.). Retrieved January 15, 2018, from https://www.isa.org.jm/workshop/workshop-design-impact-reference-zones-and-preservation-reference-zones-area

Young, O. R. (2011). Effectiveness of international environmental regimes: Existing knowledge, cutting-edge themes, and research strategies. Proceedings of the National Academy of Sciences, 108(50), 19853–19860. https://doi.org/10.1073/pnas.1111690108

Young, Oran R., & Levy, M. A. (1999). The Effectiveness of International Environmental Regimes. The MIT Press. Retrieved from https://mitpress.mit.edu/books/effectiveness-international-environmental-regimes