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Mining at 2,500 Fathoms under the Sea: Thoughts on an Emerging Regulatory Framework

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Abstract – An industry to recover mineral resources on the abyssal plains is emerging. Albeit at an explorative stage in areas beyond national jurisdiction, the commercial mining of seafloor non-living resources containing strategic metals is a realistic proposition, spurred by the demand for renewable, low-carbon energy infrastructure. The achievement of worldwide techno-economic growth must, under the principle of sustainable development, be coupled with the protection of the marine environment and its natural resources. Overall, this presents not only challenges to the development of mining technologies, but also tests the resilience of international standards governing the regulation of mining activities at great depths, including the development of the highest standards of environmental protection ab inito. This paper explores the approach being taken by the International Seabed Authority in advancing the legal regime for the regulation of mining activities in the Area, and in particular the tools and mechanisms targeted toward the protection of the marine environment.

Keywords – common heritage of mankind, International Seabed Authority, regulating risk, environmental management, ocean mining technology

1. Introduction

After a prolonged delay in the commercial recovery of marine minerals at great depths, it is feasible that the first mining venture to recover polymetallic nodules from the abyssal plains of the Pacific Ocean will be operational within a decade. Located at depths between 4,000 to 6,000 m between the Clarion and Clipperton Fracture Zones (CCFZ), an area of some 5.48 million square kilometres, these nodules contain relatively high concentrations of strategic metals. Drivers for commercial recovery include the development of green and emerging technologies as concentrations of land-based are decreasing (Hein et al. 2013; Arroba et al. 2017), and a foreseeable increase in global energy requirements to extract copper from declining ore grades on land (Harmsen et al. 2013). While preliminary economic assessments for the recovery of marine minerals and processing are promising (Lipton et al. 2018), technology trials have yet to be undertaken at a commercial scale to demonstrate the economic viability of a future mining operation, albeit successful pilot trials have taken place at shallower depths in national waters in respect of seafloor massive sulphides.

Polymetallic nodules, together with the seabed, subsoil and other mineral resources (seafloor massive sulphides (SMS), cobalt-rich ferromanganese crusts (CRC)) found beyond the limits of national jurisdiction (known as the Area), are the common heritage of mankind (CHM). The principle of the CHM maintains that there can be no private or State ownership of this common space and its resources, with access being controlled and managed by nations co-operating through an international organisation, the International Seabed Authority. This legal mechanism was established to prevent a scramble for the resources by technology-advanced countries, and to ensure that activities (marine scientific research, exploration, exploitation) would benefit mankind as a whole, in particular through the equitable sharing of financial and economic benefits with the international community. The policy objectives of the international regime include the promotion of the effective participation of developing States in activities, the increased availability of metals to world markets to satisfy consumer demand, and to compensating those developing countries whose economies will be seriously affected by mineral production from the Area.

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The International Seabed Authority (ISA) was created by international agreement under the United Nations Convention on the Law of the Sea (UN/OLA 1982). To date the ISA has awarded, and regulates 29 exploration contracts, held by a mix of private and public sector enterprises, with some 16 contracts relating to CCFZ in respect of polymetallic nodules (ISA 2018a). The contracts confer the exclusive right on an operator (contractor) to explore for the specified category of resource in a defined exploration area, in accordance with the terms of the contract and applicable exploration regulations (ISA 2010, 2012, 2013a). The regime also requires that contractors are sponsored by a State party to the UNCLOS, who has a "responsibility to ensure" that its sponsored contractor complies with its contract with the ISA, and to assist the ISA in securing such compliance.

With 15-year initial terms, and the possibility for 5 year extensions in prescribed circumstances, each exploration contract requires a contractor to carry out a programme of exploration activities in order to assess the factors to be taken into account in the exploitation phase.

In view of the prospects for commercial recovery, the ISA is progressing a regulatory framework for mineral exploitation, including the adoption of mining standards and practices relating to operational safety, conservation of the resources and the protection of the marine environment. This is a particularly challenging and complex task for the ISA, its member States and stakeholders. There is a need to produce a framework that is commercially viable and one that provides for legal stability for investors to make the necessary commercial decisions, while ensuring that the environmental effects of mining activities are monitored and appropriate mitigation techniques deployed. Equally, the regulatory framework must be developed under principles of inclusiveness and fairness, with a wide participation from members of the ISA and stakeholder base.

This paper outlines recent developments by the ISA in developing rules, regulations and procedures for the exploitation of the resources of the Area, and focuses on the tools and measures to ensure the effective protection of the marine environment from harmful effects which may arise from mining activities.

2. Regulatory Development: Exploitation

In August 2017, the ISA issued a first set of consolidated draft regulations on exploitation of mineral resources in the Area for public comment (ISA 2017c, 2017d). Being the product of a four-year consultation exercise with ISA stakeholders, the draft was based on comments to previous working drafts, discussion papers (ISA 2017a), and feedback from expert workshops.

The Council, the executive organ of the ISA, embarked on its first substantive evaluation of the draft regulatory framework in March 2018, in particular an analysis of common themes arising from stakeholder submissions (ISA 2018c). Following the meeting of the Council, the Legal and Technical Commission reviewed the draft regulations in conjunction with the ISA Secretariat (ISA 2018f), taking account of the requests made by the Council (ISA 2018d), and stakeholder submissions (ISA 2018j). Based on the Commission's comments, the ISA Secretariat issued a revised draft text in May 2018 as a working paper for consideration by the Commission at its July 2018 meeting (ISA 2018g). The revised draft (draft regulations) reflects a clearer articulation of the pathway from exploration to exploitation; an improved structure and flow; further developments in key terms and phrases; expanded environmental regulations, and improved regulatory text and timelines. The draft regulations also place an emphasis on a duty to co-operate and to the sharing and exchanging of environmental information between various actors.

The draft regulations consolidate a number of subject matters including environmental protection and inspection. This will facilitate an environmentally-integrated approach to the management of mining activities. The draft regulations do not seek to address every aspect of mining activities in detail. The aim is to present the essential components of the application process, outline key rights and obligations including management and administration consistent with the UNCLOS. Implementation of the regulations will be supported by a suite of standards and guidelines (to be developed).

The draft regulations presented are generic, and their provisions applicable to all mineral resource categories. Though some stakeholders have called for resource-specific regulations, this would seem unnecessary. While it is acknowledged that for each resource type different geological and environmental characteristics exist, and that different mining technologies will be deployed, it is preferable that such differences are taken into account through resource-specific standards and guidelines, including appropriate mitigation techniques.

Similar to exploration, an applicant for the approval of a plan of work for exploitation has to demonstrate to the

Commission that it has the necessary financial resources and technical ability to undertake exploitation activities. Following any recommendation for approval of a plan of work by the Commission to the Council, a contract is concluded between the ISA and an operator (contractor). The contract provides the necessary legal link between the contractor and the rules, regulations and procedures adopted by the ISA, including rules relating to the effective protection of the marine environment.

The ISA's role, and key policy objective as a regulator in terms of environmental protection is principally that of regulating the risk (and uncertainty) presented by future mining operations and their associated environmental effects.

3. Risk Assessment of Mining Operations and Related Environmental Effects

While there will be differences in mining technology between resource categories (a dredging-style operation in the case of nodules, a cutting operation in the case of SMS and CRC) there is similarity in that the resources will be broken up in a collector at the seafloor, and returned, as a slurry, through a fully enclosed riser system to a mining support vessel at the sea surface. The slurry (mineral-bearing ore) will be dewatered (shipboard processing), and the ore transferred to an ore barge destined for onshore processing. The processed return water will be discharged back into the water column at a height above the seafloor to minimise plume creation, and at a depth to minimise temperature variations between the water discharged and surrounding water temperature (Collins et al. 2013).

Despite the size of a typical nodule exploration area (75,000 km^2), only economically viable nodule fields will be mined with anticipated mining technology. A single mining operation producing at a rate of 3.0 million tonnes per year over 20 years, implies a mining area to be directly impacted of 8,500 km^2, assuming an average nodule abundance of 7 kg/m^2 (Madureira et al. 2016). The actual size of the mined area could be reduced due to higher nodule abundance values, and mining efficiencies due to technology improvements (Sharma 2011). In terms of magnitude, the directly impacted mining area for a single operation equates to less than 0.2% of the total area of the CCFZ, albeit the geographic footprint (plumes) will cover a wider area. For other mineral resources, such as SMS, such footprint will be on a much smaller scale.

Mining activities will have spatial and temporal implications with varying degrees of severity. Effects will extend beyond the local mining site, and be either of a short or long duration; some effects may be negligible, while others at a localised level may be severe. The removal of substrate will have the most profound impact on endemic species; the associated plume arising from the movement of the miner across the seafloor creating suspended sediment may impact the water column resulting in oxygen depletion, metal toxicity and enriching the column with organic nutrients; a re-sedimentation process may bury organisms in the immediate and adjacent mining areas, together with the effects of the discharge of waste processing water and material. Ancillary impacts include malfunction (cracks or fractures) in the lifter systems, hydraulic fuel leaks, ore spills during vessel transfers, noise pollution via machine vibration, electromagnetic fields around umbilical cords attached to remotely operated vehicles, and the introduction of light which may affect bioluminescence organisms.

The design of mining equipment needs to factor in the above impacts as far as possible, to minimize the penetration depth of the mining collector in the case of polymetallic nodules, and to reducing plumes and consequential re-sedimentation effects.

The need to undertake an environmental risk assessment to duly inform the components of the marine environment at risk from the above activities, including pollution is a pre-requisite under the draft regulations. A risk assessment will help inform the appropriate studies and investigations to be undertaken as part of an environmental impact assessment, and subsequent formulation of mitigation and risk management measures. Risk assessments should incorporate a "likelihood-consequence" approach; such an approach is a factor of the expected likelihood of an event and its expected consequence.

Determining the connection between particular impacts and the likelihood and consequence of such impacts together with ecosystem and biological responses remain challenging. As advanced in a CCAMLR context in a data-poor environment "a pragmatic approach is to acknowledge that the ecological consequences of human impacts are likely to remain unknown and to focus instead on managing the [effects] themselves on the assumption that impact reduction is desirable no matter what the actual shape of the relationship between impact and risk" (Sharp et al. 2009).

4. Baseline Data and Environmental Assessment

Prior to the commencement of any mining activities, the characteristics of the receiving environment need to be documented. Under an exploration contract, contractors are obliged to gather baseline data, to establish such baselines, and to establish a programme to monitor and report the effects of its exploration activities, including any testing of equipment, on the marine environment against such baselines. These data will support the documentation of environmental conditions prior to mining identified areas, be the primary input into an environmental impact assessment (EIA) process, and preparation of an environmental impact statement (EIS, being a report on the outcome of an EIA) as part of an application for an exploitation contract. The Commission's recommendations for the guidance of contractors relating to assessment of the possible impacts arising from exploration for marine minerals in the Area sets out the seven categories of baseline data requirements (ISA 2013b). Under an exploration contract, contractors must observe such recommendations "as far as reasonably practicable".

The characterisation of the marine environment in respective exploration areas remains a priority focus for the ISA and its contractor base. Further environmental surveys are required and their results evaluated as part of an EIA. A clear focus at this stage of exploration should be the standardisation of data gathering and analysis. To this end, a data management strategy and plan is being implemented by the ISA (ISA 2016). Aside from building a fit-for-purpose data management platform, it will highlight data gaps that need to be filled, and offer the opportunity to assess new approaches to standardisation in data collection and reporting. This will ultimately provide the ISA and stakeholders with data and information for informed decision-making in respect of regional planning and management, and, where applicable, modifications to the regulatory framework (adaptive governance).

There do remain a number of barriers to establishing baselines in proposed mining areas, and adjacent areas subject to secondary impacts including: a poor understanding of the natural evolutionary processes, water dynamics, data collection and methodology has not been standardised, and a lack of species data. Though in the CCFZ, it has been recorded that the lack of reporting for species data, is likely a consequence of "insufficient observational and taxonomic work", rather than a lack of sampling (Lim et al. 2017).

The effectiveness of subsequent monitoring programmes is highly dependent on an adequate baseline, as is the development of appropriate mitigation and advance response strategies to conservation, rehabilitation and natural remediation of biological diversity and ecosystem functioning, and to ensure progressive improvements in environmental management standards. Though monitoring is expensive and needs to be targeted at effects predicted by the EIA (ODPM 2002).

Standardising an EIA assessment process will also be a key consideration. The draft regulations require an EIS (annex IV, ISA 2018i) based on the EIA as part of an application for a plan of work. The technical parameters for the conduct of an EIA have yet to be outlined by the ISA. The evaluation of an EIA by the Commission, and adequacy of underlying baseline studies will be a complex process. Neither objective assessment criteria nor guidance on what will be considered by the ISA as acceptable effects on the marine environment have been put in place. The "adequacy" or "sufficiency" of an EIS should be addressed in ISA guidelines, including further guidance on temporal approaches; though spatial approaches have been given due attention, temporal aspects remains for further analysis (Durden et al. 2017).

The approval mechanism will be an iterative process between an applicant and the Commission, with additional input from the ISA Secretariat, recognised experts and comments from the ISA stakeholder base. This may result in agreed modifications to the EIA and environmental management and monitoring plan. Such modifications may include site or project-specific conditions and restrictions (e.g. on mining discharges) that an applicant will need to comply with.

5. Management, Monitoring and Reporting

The draft regulations house a number of procedural tools and mechanisms to ensure the effective protection of the marine environment, including the ISA's due diligence obligation to assess the financial and technical capability of an applicant for an exploitation contract. This is exercised through the Commission who must consider, *inter alia* an applicant's financial and technical capability: to carry out a plan of work in accordance with good industry practice; to implement an environmental management and monitoring plan; to execute and implement an emergency response and contingency plan, and that the applicant can modify its management and operating procedures in the light of monitoring results. This due diligence process is also supplemented by a

stakeholder (public) comment mechanism.

What is less clear in the draft regulations is the extent to which the ISA will review a contractor's financial and technical capability throughout the mining-life cycle. Though the draft regulations provide for a periodic review of contractor activities, including a review where certain prescribed events or a change of circumstances occurs, the detailed content and process for such a review remains to be developed through guidelines. The outcome of such reviews will be made public availability, except for confidential information.

As part of the assessment and approval process, applicants are required to submit an environmental management and monitoring plan (EMMP). An EMMP forms a key component of a plan of work; the implementation of its provisions are a contractual requirement. The broad content of an EMMP is prescribed for in the draft regulations at annex VII, though detailed guidance will be required in due course as to its preparation. The EMMP must also be prepared in accordance with any applicable regional environmental management plan in place at the time.

The purpose of an EMMP is two-fold. First, it provides direction and focus to a contractor's environmental management of its exploitation operations, based on the outcomes of the EIA process (which must be dynamic as new learnings emerge). Secondly, it also provides a reference point for the regulator for inspection and enforcement purposes. There are three implementation stages for an EMMP: mitigation measures (including adaptive management techniques), monitoring the impacts of potential significance or uncertainty, and an evaluation (and revision) process being a product of monitoring and assessment. This is particularly crucial for monitoring cumulative impacts which may be uncertain or unknown at the time of the completion of the initial EIS and EMMP. The need for a regular assessment of a contractor's performance and measures implemented under an EMMP is paramount, together with a review of the appropriateness and adequacy of an EMMP. This is addressed by the draft regulations which provide for the frequency of performance assessments and review by the Commission.

Mitigation measures have yet to be fully developed and formulated in response to the effects of mining activities. It is suggested that two main areas be considered, namely: restricting the size of the mining area such that ecosystem integrity is not compromised, and control over the area affected by secondary impacts, from the mining plume and the settling of plume sediments, by managing the reduction in sediment disturbance (MIDAS 2017). The objective is to ensure that "there are no adverse effects on the overall integrity of the wider ecosystem in areas targeted by mining" (MIDAS 2017).

Effective monitoring is a pre-requisite of good environmental management. Monitoring will show the results of predicted effects on the marine environment and identify any additional risks. Monitoring will aid in the understanding of as to whether mitigation measures have been implemented, their associated success, and whether intervention is required and measures adjusted accordingly. Monitoring and reporting requirements will drive improvement in the design of the future EIA content and assessment process. Monitoring and reporting may also trigger a fresh EIA approval requirement where there is any material change to the nature of the activities first envisaged or to the information supporting the original application. This aspect does require attention in the draft regulations as to the trigger points or events requiring a new EIA, EIS and EMMP together with a stakeholder comment process. Additionally, while the draft regulations place an emphasis on monitoring obligations through an EMMP, the ISA must develop appropriate guidance for the conduct of monitoring programmes by drawing on existing guidance from parallel regimes (e.g. CPA 2011).

As part of its monitoring obligation, contractors must also designate in their EMMPs impact reference zones (IRZs) within a mining area, and preservation reference zones (PRZs) in accordance with the Commission's guidance (ISA 2013b). PRZs are control reference sites outside of the mining area and not impacted by mining operations. PRZs may also act as an exclusion zone to protect benthic communities, providing a refuge for organisms and a potential source for species recruitment to mined areas (Van Dover 2011). To what scale and extent PRZs should be included is yet to be defined, with one report suggesting that multiple zones will be required together with larger scale no-mining areas (areas of particular environmental interest) put in place across nodule fields (MIDAS 2016). But design recommendations must be formulated (Van Dover 2011). To this end the ISA hosted a workshop in September 2017, the recommendations of which are awaited (ISA 2017e). In due course, further guidance is required as to the content of monitoring programmes, including standards relating to data sampling and analysis to ensure consistency in reporting across the contractor base.

The draft regulations require an EMMP to be delivered at the application stage and, where a material change needs to be made, a revised EMMP at least 12 months prior to the

commencement of production. This does introduce an element of regulatory risk for a contractor as production may not commence until any revised EMMP is approved by the ISA. However, given that project feasibility will only take place post the award of an exploitation contract, involving detailed engineering studies, the delivery of a revised EMMP should provide a higher degree of confidence in the EMMP by stakeholders as its content is fully developed.

The ISA also requires a closure plan in the form set out in annex VIII to the draft regulations. The closure plan will incorporate post-closure monitoring and mitigation requirements, and may include details of restorative measures. The monitoring timeframe post closure of a mining operation still requires consideration, and the extent to which that monitoring relates to the risk of significant residual effects, and the success of the recolonization of species. That said, the purpose and objectives of a closure plan is yet to be fully discussed with the stakeholder base.

The draft regulations also anticipate that the Commission and applicants will negotiate amendments and modifications to a plan of work. In many regulatory environments, specific conditions will attach to the granting of mining permits and environmental authorisations. In terms of such conditions, guidance could be taken from the marine dredging industry. In the United Kingdom, dredging operations are controlled by conditions attaching to a dredging license in addition to the requirement of environmental impact assessment and monitoring (ODPM 2002). These conditions are intended to minimise the impact of dredging activities on the marine environment, including cumulative impacts from adjacent dredging sites and other human activities. These conditions include: operating within discrete sub-areas; restricting activities at a critical times of the year to minimise the effects on recruitment of benthic communities; restriction on on-board screening of the ore slurry; specific monitoring obligations and trigger points for corrective action; fitting of an electronic monitoring system to monitor that operations are confined to the dredging area; ongoing surveys and studies. It is acknowledged that dredging occurs in shallower waters where our knowledge of effects is at a more advanced stage. Furthermore, dredging activities occur in areas of intense human activity with the potential for significant cumulative effects on the marine environment to be realised.

Other conditions that could be negotiated include: the maintenance of a specific category of insurance; the provision of an additional financial guarantee (an environmental performance guarantee is a mandatory requirement under the draft regulations); independent auditing and verification of an EMMP, together with other review and reporting conditions (e.g., see also MFENZ 2012).

Little consideration has been given to the above to date. The focus of the draft regulations has largely centred on the broad content of an EMMP, and procedural obligations.

Additionally, there is a trend in regulatory policy approaches toward outcome based regulations. This approach arguably provides for greater flexibility in innovation, and contributes toward an adaptive management approach (see below). A result-oriented approach places the duty on a contractor to assess and manage risk to ensure delivery of pre-agreed environmental targets. This is both preferable from the viewpoint that the operator is better suited to managing risk, particularly given the remoteness of potential mining activities. For example, the Environmental Protection Authority of Western Australia's preference is:

"to recommend outcome-based conditions. That is, conditions which focus on the ultimate objective that is to be achieved (in contrast to prescriptive conditions, with detailed requirements about "how" to achieve the objective). The aim of the outcome-based approach to condition-setting is to regulate 'what' to achieve, not 'how' to achieve it." (EPAWA 2012).

The ISA should foster the development of result-oriented targets (technical standards) that clearly define an intended outcome toward the protection of constituent elements in the marine environment (ISA 2017a), and to avoid specific environmental effects. These could include quantitative technical thresholds, parameters and indicators; for example, the location of returned water discharges, sedimentation thresholds (thickness and distance from the mining activity), suspended particle limits from the plume in the water column (the boundary mixing zone, the point at which the effect of the mining plume on the marine environment can be considered negligible), and noise pollution limits. Appropriate monitoring (to measure performance against a specified outcome) and reporting protocols to the ISA would also need to be put in place. The reporting of monitoring results will be a key component of EMMP delivery to assess performance, measures and actions taken and the review and revision of such measures and actions.

To the extent that legal or ecological thresholds are specifically designed for the deep-sea environment, these must reflect a sufficient buffer between a target reference point (where

corrective measures should be implemented by a contractor prior to reaching any limit reference point) and a limit reference point (threshold), the exceeding of which would trigger contingency action by a contractor and enforcement action by the ISA, including possible penalties.

While the UNCLOS provides for the issue of "emergency orders" by the ISA to contractors to prevent serious harm to the marine environment, the practical and timely application of such orders, given the remoteness of future operations, is questionable. The draft regulations do however provide for the implementation of a contractor's emergency response and contingency plan, coupled with notification and reporting procedures as a regulatory response to incidents.

The science connected with the deep-sea environment lags behind that of the terrestrial environment to establish meaningful ecological thresholds at this point. Consequently, a more qualitative approach is required until further research is advanced, including the development of autonomous monitoring systems (MIDAS 2017). To the extent a component of the marine environment cannot be measured, the EMMP should identify the proposed management actions to minimise environmental effects as far as practicable (EPAWA 2017).

6. The Role of Standards

In addition to the technical standards discussed above, other performance and process "standards" (to be adequately defined) play an important function in the operationalisation of the regulations, and in ensuring a consistent approach to environmental management across mining operations. Aside from on-site inspections and use of remote monitoring technologies, the industry will principally self-regulate. Standards will underpin the application of good industry practice, and allow the ISA to assess contractor performance against such objective standards. Contractors are obliged to undertake mining activities in accordance with good industry practice (defined by a reference to applicable standards adopted by the ISA) and best environmental practice. Consequently, the content and dynamic nature of these terms, in time and space, requires further analysis given such terms will be fundamental in supporting the delivery of best practice under a legal framework, and the orderly, safe and rational development of mining activities.

The role of and developing environmental standards in the Area has been the subject of workshop discussion (ISA 2017f). Additionally, the Commission has been tasked by the Council to consider a workshop in connection with standard and guideline development (ISA 2018c), and to consider the appropriate legal status of such standards and that of guidelines. The draft regulations require that standards are to be approved by the Council, based on the recommendation of the Commission. Albeit "applicable standards" are incorporated into the definition of good industry practice, specific technical standards must be developed and adopted in the EMMP (e.g. environmental thresholds).

As to guidelines, the Commission and the Secretary-General may issue guidelines of a technical or administrative nature, with the Council having an oversight role. The standard contract clauses in the draft regulations require contractors to observe guidelines "as far as reasonably practicable".

Further discussion is required on how to better embed standards and guidelines across the regulations, the exploitation contract and the plan of work. The legal status of individual standards and guidelines, being mandatory or recommendatory in nature, will require determination, based largely on the significance of its content (ISA 2018h).

In order to ensure stability in the legal framework, standards and guidelines should be developed through a transparent and inclusive process. The adoption of standards, that are industry-specific and cost-effective in their application, requires a consensus-building approach.

There is a plethora of standards and guidelines used by and developed under land-based mining regimes and the oil and gas industry that can be adopted, modified or their principles applied by the ISA. These include standards developed by the International Organization for Standardization (e.g., ISO 14001:2015 (environmental management systems); ISO 31000:2009 (risk management principles)); various assessment frameworks, for example, storage of CO_2 streams in geological formations (OSPAR 2007), and in the petroleum sector, guidelines for offshore environmental monitoring (CPA 2011). There is little merit, if not a danger, in re-inventing the wheel.

The formulation and adoption of guidelines will facilitate the dissemination of good industry practice, best environmental practice (BEP) and techniques. Although such guidelines may be non-binding legally, they establish a considered code of best practice, and are more flexible to adaptation in the light of new knowledge and experience than core regulatory provisions requiring formal amendment by the ISA Council and Assembly.

7. Adapting to Improved Knowledge

An important feature of the exploitation regime will be the level of "control" exerted by the ISA in securing contractor compliance, and the ISA's perception as a "good" regulator. The vast majority of mining and oil and gas models now tend toward self-regulation with the necessary checks and balances put in place through reporting, notification and inspection / auditing mechanisms together with enforcement tools. While this is perhaps of greater significance given the remoteness of future mining operations, it also ensures that risk is placed in the hands of those best to manage it i.e., the operators.

In adopting a legal framework there must be a balance between rules based on existing knowledge (best available scientific evidence) and best practice to create a stable, certain and predictable legal regime in the Area, and one that must also respond and adapt as new information comes to light about ongoing mining activities and their effect on the marine environment.

The initial term of an exploitation contract is a maximum of 30 years, with renewal periods of up to 10 years being granted under prescribed circumstances. Draft standard contract terms, while providing for security of tenure, also create an obligation to "comply with the Regulations, as well as other Rules of the Authority, as amended from time to time". Consequently, contractors are subject to the terms and conditions of the contract (which may only be amended by an agreement of both parties), and the obligations prescribed for by the regulations (which may be amended unilaterally by the ISA under its review procedures in the light of improved knowledge or technology). Contractors and investors seek certainty and stability. The ISA as a regulator, while seeking to attract investments and technology to the Area, must also foster adherence to best practices as new knowledge and information increases. This is particularly important in connection with the protection of the natural resources, both living and non-living. While this process is not uncommon under land-based mining regimes, there is a greater degree of commercial and investor sensitivity in connection with a frontier industry, and toward a new and inexperienced regulator. Ensuring that any proposed significant changes to the regulations are only adopted and implemented following relevant stakeholder consultation is an imperative to achieving good regulation, and a stable and predictable regulatory regime.

From an operational perspective, adapting to new information leads to the consideration of adaptive management. Adaptive management is "a planned and systematic process for continuously improving environmental management practices by learning about their outcomes. Adaptive management provides flexibility to identify and implement new mitigation measures or to modify existing ones during the life of the project" (CEA 2009). While generally accepted as good management practice in any industry, its application in a frontier industry to close the gap between certainty and uncertainty, merits further thought.

The challenge for the ISA is the extent to which it should prescribe and regulate for adaptive management measures versus say setting appropriate thresholds and trigger points (technical standards) and allowing a contractor to adaptively manage its own operations and develop the necessary management responses. As documented, adaptive management is a cyclical process. Most business models are linear. A temporary suspension in mining operations or an alteration in recovery rates (a stop, start approach) in order to monitor and assess environmental effects, could have a detrimental impact on the economic viability of a mining project. That said, the two are not mutually exclusive and focus should be given to the planning of projects and design of decision-making structures. Under the draft regulations, a description of adaptive management techniques is required under an EMMP.

The aim of adaptive management is to reduce uncertainty over time through an iterative process of monitoring and evaluating the management and mitigation measures implemented, and adjusting such measures to meet an outcome or objective under an adaptive management framework. It is forward looking, albeit there is a need to balance this with securing effective protection in the short-term based on existing knowledge (MFENZ 2016).

The challenges faced by commercial operators in a marine mining context, and the practical implementation of adaptive management has been well documented in New Zealand (MFENZ 2016). New Zealand's legislation prescribes for an adaptive management approach which includes "allowing an activity to commence on a small scale or for a short period so that its effects on the environment and existing interests can be monitored", and "any other approach that allows an activity to be undertaken so that its effects can be assessed and the activity discontinued, or continued with or without amendment, on the basis of those effects" (MFENZ 2012). It

is self-evident that this creates a tension between the economic viability of a project, and managing a tolerable level of risk of harm to the marine environment.

Adaptive management does not replace the need for adequate data collection and a good baseline, so that the appropriate thresholds and trigger points can be identified requiring management or regulatory responses. Indeed, shortcomings in New Zealand marine consent applications can be attributed to inadequate information and a consequential lack of confidence by the decision-makers in the adaptive approach being put forward to address uncertainty within the applications.

Adaptive management is arguably an application of the precautionary approach; the latter does not advocate that mining is banned until scientific uncertainty is resolved, but that it proceeds with necessary controls and risk mitigation measures put in place (Collins et al. 2013). Certain risks will be "acceptable"; what is acceptable will also be a factor of the costs or efforts needed for its further reduction. In connection with the safety of oil and gas operations, this is articulated as follows:

"Operators should reduce the risk of a major accident as low as reasonably practicable, to the point where the cost of further risk reduction would be grossly disproportionate to the benefits of such reduction. The reasonable practicability of risk reduction measures should be kept under review in the light of new knowledge and technology developments. In assessing whether the time, cost and effort would be grossly disproportionate to the benefits of further reducing the risk, regard should be had to best practice risk levels compatible with the operations being conducted." (EU 2013).

Prescribing for adaptive management has an inherent danger: one of overregulating commercial mining operations, leading to increased and unnecessary monitoring and mitigation costs. A number of procedural challenges have also been raised in that adaptive management could impact the security of tenure under a contract (Jaeckel 2016).

Operators are best placed to determine an adaptive management approach as they better understand the uncertainties in a project, and the technology and methods to be deployed to manage such uncertainties (MFENZ 2016). Adaptive management is not an absolute; it is a process tool to deliver improved ways of doing things. Ultimately, the burden of proof will be on a contractor to demonstrate that it has adhered to best practice.

Applicable practices relating to adaptive management measures should be driven by the industry in response to the environmental objectives, conditions and outcomes set by the ISA. A possible environmental management framework reflecting the implementation of the precautionary approach and adaptive management measures has been advanced elsewhere for consideration (Durden et al. 2017).

The central role to be played by technology in advancing solutions toward the environmental management of mining activities must be better understood. The testing of technologies at an early stage will be an important component of the sequencing process of adaptive management particularly as the consequences of potential mining impacts are not well understood. Such testing is likely to reveal key information as to the impact of mining activities, particularly in connection with plumes, and the design and implementation of best available techniques for mitigation.

8. Advancing Technology through Best Available Techniques

The Commission's recommendations for the guidance of contractors relating to assessment of the possible impacts arising from exploration for marine minerals in the Area (ISA 2013b) lists certain exploration activities as requiring a prior environmental impact assessment, and a monitoring programme. This includes the testing of collection systems and equipment. The recommendations also make reference to the use of "best available technology" in connection with setting up the environmental baseline, and the "best available technology and methodology" for sampling to establish such a baseline.

The role of "test mining" has been the subject of some discussion and debate across the stakeholder base (ISA 2017f), and in submissions to prior draft regulations. Aside from the use of inconsistent, and at times confusing terminology ("test mining", "mining tests", "pilot mining tests"), a question arises as to whether the testing of equipment should be mandatory prior to an application for an exploitation contract, together with the specific conditions and requirements of such testing activity.

There is no regulatory obligation to conduct "testing" under the exploration regulations, nor is it a specified requirement under the draft exploitation regulations for an exploitation application. Given the levels of capital expenditure required for testing, the decision on such activity, its level

and timing, is primarily a commercial one. In practice, however, some level of testing is inevitable. Indeed, the mining process is a modifying factor in determining the conversion of mineral resources to mineral reserves (ISA 2015b), a key determinant to project viability, approval and funding.

Two levels of testing are envisaged. First, the testing of components of a mining system on a smaller scale (e.g. collector engineering tests) is likely to be undertaken by contractors at the exploration stage to validate the reliability of the component (i.e., that recovery of the mineral resource is technically achievable), and to evaluate the economic viability of a mineral resource to advance work toward a pre-feasibility and feasibility stage.

Secondly, the testing of an integrated mining system (integrated testing), where all components of a system are assembled, the minerals transported to a mining vessel at the sea surface together with mining discharges following shipboard processing. Given its high cost, integrated testing is unlikely to be advanced until the feasibility stage of the mining project, and post the award of an exploitation contract.

Concurrent with any test, in addition to the ongoing gathering of environmental baseline data, the monitoring of any component testing will ground truth data and improve the current state of knowledge of expected impacts at the commercial mining phase. A monitoring plan is a requirement under the Commission's recommendations (ISA 2013b). It is expected that two contractors will undertake component tests for collectors during 2019 in their respective contract areas in the CCFZ under the JPI Oceans MiningImpact project. Though a possible weakness of the ISA recommendations is there are no guidelines to adequately inform the principal content and deliverables of a monitoring plan; this is largely left to a contractor to determine.

Best available techniques (including technology) is a regulatory standard applied in many industry sectors. As a concept, its assessment in mature industries is well understood, it remains challenging as deep-sea mining technology is under development, and limited testing has been conducted in the target environments. Under the draft regulations, contractors are required to apply best available techniques in carrying out measures to ensure the effective protection of the marine environment. The capability of an applicant to utilise and apply such techniques must also be assessed by the Commission as part of the application process, though the ISA is not in a position to specify the particular equipment, procedures and techniques that comprise the concept of BAT. Further discussions are likely to occur in respect of the technology and procedures to be deployed as they relate to avoiding or minimising environmental effects, and their consideration as part of the application process, including accreditation of equipment by an international accreditation body against industry-agreed technical standards (ISA 2017b).

A contractor will be required to adopt BAT during the mining life cycle, and demonstrate at the application stage that it has the technical capability to do so, including in connection with limiting waste and discharges, mitigation (e.g., in connection with plume generation), monitoring techniques and procedures, and the technical capacity to monitor key environmental parameters including technical thresholds. The concept should also be applied to human health and safety. Though the draft regulations provide a broad definition of BAT, given its dynamic nature, criteria will be developed by the ISA to take account of its change over time and in the light of new knowledge and technological advances. Such criteria should also reflect cost-benefit considerations, particularly where any "incremental benefits are clearly insufficient to justify the incremental costs of using such technologies" (US/GPO 1989).

The draft regulations also provide inter alia that contractors shall reduce the risk of incidents to as low a level as is reasonably practicable. Technology will play a major role in managing the risk of incidents, as it will in connection with the requirements to take all reasonable and practicable measures to prevent or minimize marine pollution, and to take all reasonable and practicable mitigation measures to protect the marine environment.

An important feature of the rules will be to ensure that the approved operating parameters are complied with in terms of resource extraction methods, and that mining operations are confined to approved areas. The deployment of an electronic monitoring system (EMS) which both tracks the movement of mining collector equipment and gives a picture of the intensity of mining operations should be deployed. The EMS data can be sent remotely to the ISA for assessment, and generation of an "irregularity notice" where mining has occurred outside an approved area. The EMS has been successfully deployed by the United Kingdom's Crown Estate since 1993 in respect of marine dredging operations.

9. Beyond the Regulatory Framework

There is a need to go beyond the existing regulatory

framework (licensing, standards) and develop other environmental policy instruments which support environmental objectives, including restoration, market-related instruments and possible future payments for any loss in ecosystem services (UNEP 2007).

The assessment of the technical and economic feasibility of implementing restoration measures should be considered as one policy approach in addressing serious harm to the marine environment (ISA 2015a). It will be important to assess this against ISA environmental objectives, and whether resources are warranted to make such interventions. While further studies need to be undertaken, there are early indications that the deployment of artificial substrates could enhance local species recruitment, though this should be considered in conjunction with mitigation measures relevant to each ecosystem and locality (MIDAS 2017; Van Dover 2011).

As to economic incentives, the ISA's discussion paper on environmental matters (2017a) noted the use of market-related instruments to facilitate delivery of environmental objectives, targets, performance, and to support technology development and innovation. In discussions on the development of financial terms for exploitation contracts (being payment terms to compensate the common heritage of mankind as resource owner) consideration has also been given to a number of financial mechanisms to protect environmental resources through incentivising a reduction in the likelihood and magnitude of environmental harm in a cost-effective way, and to provide for compensatory measures through funds.

The policy approaches that could be adopted by the ISA toward environmental protection and to foster sustainable mining activities include a range of instruments: regulation; funds, bonds (financial guarantees) and insurance, fees and a liability mechanism. These approaches, either individually or in combination are discussed in some detail elsewhere (Lodge et al. 2017). The choice of which approach or approaches to take requires consideration of the needs related to managing environmental risk, and then identifying the appropriate mechanism(s), including market-based tools, to address those needs. For example, bonds may be connected with securing monitoring obligations post closure of mining operations, and a fund as a longer-term compensatory mechanism for residual and significant environmental effects. In connection with advancing a more coherent liability mechanism in the Area, a working group has been set up to explore these issues in greater detail (CIGI 2017).

10. Concluding Remarks

The ISA must advance draft regulations based on the best available information. The regulatory process must also encompass the collective views of mankind, while resisting unilateral or regional trends with different perceptions on the existence value to be placed on biodiversity at risk. Such trends may undermine the objectives of the UNCLOS, and its contribution toward the United Nation's sustainable development goals. The UNCLOS is a visionary instrument, enabling the mining of mineral resources at great depths, but with appropriate safeguards for environmental protection.

In developing the resources of the Area, we may have to accept that the recovery of mined areas to their former baseline condition may take place in the long term, measured by centuries or millennia, or perhaps not at all. Such effects, and their extent, will vary by the resource category and areas mined and the technology deployed. The significance of such effects is as yet undetermined. Where uncertainty prevails, an inevitable political decision will be required as to levels of acceptance or tolerability of environmental damage. With 168 members, the unique governance structure of the ISA, including its observer base, both promote and facilitate a diverse and balanced discussion in opinions, and thus decision-making.

There is an important issue of magnitude and scale in any discussion connected with the effective protection of the marine environment. Mining activities are likely to have an impact at an individual organism level; endemism and the extinction of localised species do present a concern (Lodge et al. 2014). There may be a modest impact at the community level structure but at a regional (or whole ecosystem level) effects may be negligible. That is, a holistic approach to conservation and the environmental management of activities in the Area is required. The conservation (and preservation) strategy being adopted by the ISA is one of maintaining and managing as representative a sample of deep-sea species as is possible, through the designation of no-mining areas. To date, the ISA has designated some 25% (1,440,000 km^2) of the CCZ as a mining protected area, divided into nine biogeographic sub-regions known provisionally as "areas of particular environmental interest" (Lodge et al. 2014). A preliminary strategy for the development of regional environmental management plans in other parts of the Area has also been presented to the Council (ISA 2018c).

The ISA has multiple objectives and achieving an appropriate

balance between such objectives is challenging, not least in a multi-stakeholder community. These objectives and challenges are evidenced by the ISA's strategic plan for the five-year period 2019–2023 (ISA 2018e). The ISA must develop and implement measures which promote efficiency in ocean mining activities, and not promote wasteful practices or provide for disproportionate or unnecessarily bureaucratic requirements. It must learn from the outputs of other projects and programmes, including best practice in the extractive industries sector to avoid "re-inventing the wheel".

The delivery of legislation and administrative infrastructure at a sponsoring State level is a crucial element in the overall governance mechanism. Often the perceived regulatory gaps in international law do not occur at the international level but exist at a State level. This is true of the Area regime, where national laws and regulations are at best "patchy".

The ISA, its contractor base and other key stakeholders must further develop a regulatory framework in a collaborative manner by incorporating performance and process standards, together with economic incentives that foster the development of good industry practice. The ISA's policy and legal framework, informed by the UNCLOS, together with its effective functioning as a mining regulator and environmental agency, must provide a stable and predictable investment platform.

Technology and change are crucial to both the delivery of efficient mining operations to optimise resource recovery, and consequently the conservation of the resources, and to addressing environmental effects. Studies should be undertaken as to how this has been achieved in parallel extractive industries with decades of experience.

The ISA's role is to build a commercially viable framework that recognises technology and innovation as central to enable solutions being brought to the table. Overregulation will stifle innovation in a potentially viable industry.

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